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Admission and Exhaust Valves used in Petrol, Gas, and Oil Engines.

V.

By EDGAR BUTLER, M.I.Mech.E., A.I.E.E.

THE advantage gained in using two valves is more obvious in the case of large cylinder diameters than in the small motors, owing to the ratio of valve lift not keeping pace with the increase in diameter. The sizes given in the table of valve and cylinder diameters, however, are taken from the usual allowance of a lift of one quarter the valve diameter at the bottom of the seat, this ratio of lift to diameter giving approximately an equal opening to the valve area after allowing for the space taken up by the valve stem. Referring back to the table of sizes, a valve $1\frac{1}{2}$ in. diameter is allowed for a cylinder of 4 in. diameter, the lift in this case will be $\frac{3}{8}$ in. to give the full opening to the valve. Now, advancing to an 8 in. diameter cylinder, having a 3 in. diameter valve, the lift should be $\frac{3}{4}$ in. to obtain the maximum useful opening; in practice a lift probably not exceeding $\frac{5}{8}$ in. would be allowed. Again, in taking for example a still larger cylinder of, say, 24 in. diameter, and having a valve 8 in. diameter, the lift should be 2 in. to obtain the full opening capacity of the valve. It is doubtful, however, if an engine of this size, especially if constructed to run at a high speed, would have a valve lift greater than from $1\frac{1}{4}$ in. to $1\frac{1}{2}$ in.; accordingly it will be seen that there really is a good reason for using two valves to take the place of one in engines of large size; for instance, in an engine of the size last given, viz., with a cylinder diameter of 24 in., a single valve of 8 in. diameter with a lift of $1\frac{1}{2}$ in. would give an opening of about $37\frac{1}{2}$ in. area, whereas the full capacity of the valve itself is more nearly $47\frac{1}{2}$ in. area. Now, assuming that a double valve or two valves are used, giving approximately an equal area, it will be found that $5\frac{3}{4}$ in. diameter and $1\frac{1}{4}$ in. lift give an opening of 45 in. as against

$37\frac{1}{2}$ in. as in the case of a single valve of 8 in. diameter, the areas of two $5\frac{3}{4}$ in. diameter valves being equal to one valve of 8 in. diameter.

Some makers take advantage of this practice and use two exhaust valves in place of one, viz., the Gas Motoren Fabrik, of Deutz, for large power gas engines, and the Wolseley Motor Co., of Birmingham, for automobile motors. A further advantage gained by the duplicated valve is in giving one of them sufficient lead in advance of the other as to release the pressure in the cylinder before the opening of the second valve, by which means the resistance opposed to the opening of the valves is reduced by nearly a half and to some extent minimises the necessity for using a balancing piston head to the exhaust valve. The cost of the double valve, illustrated by Fig. 29, is probably less than two separate valves of equal diameter, each provided with an independent cam and lever, the double valve is moreover entirely balanced, and if arranged with some form of controlling valve which may be either as illustrated by Fig. 6, 26, or as shown in Fig. 29, it is possible to construct an engine having a very free valve opening with a minimum of seating surface exposed to cylinder pressure.

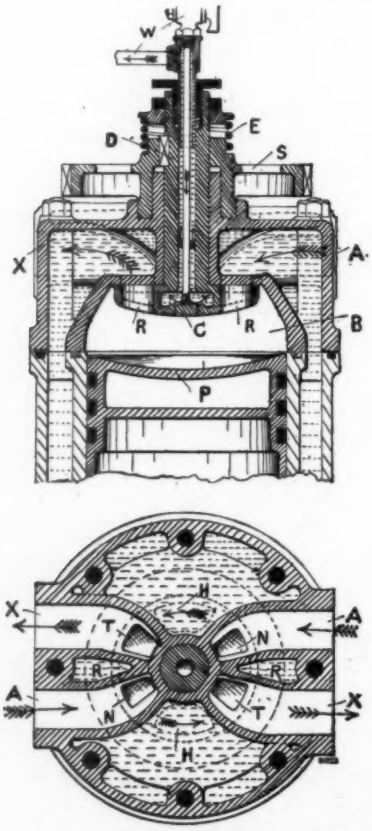


FIG. 30.—COMBINED ADMISSION AND EXHAUST ROTARY DISC-VALVE FOR VERTICAL 4-CYCLE ENGINE (RAYMOND).

Rotary Valves.

The most effectual substitute for the lift poppet valve is undoubtedly a thoroughly balanced form of self-adjusting rotary valve, many of which are in use and giving very satisfactory results. Any form of sliding valve, whether it be reciprocating or rotative must necessarily have a slow surface speed and be relieved of the major portion of the pressure resulting from the explosions. In the evolution of the internal combustion engine, many forms of rotary cylindrical and disc valves have been used with varying degrees of success. A very good example of a disc valve is illustrated by the "Raymond" valve, Fig. 30, which represents a section of a cylinder used in a 100 h.-p. 4-cylinder vertical gas engine, made by Case & Co., of America. In order to reduce the surface friction in this instance a ball was used, thus taking up the great pressure tending to force this large diameter disc against the seat on the cylinder cover. This detail is not shown in the illustration for the sake of clearness; the rolling path was, however, arranged in some engines between the ports and the valve stem, and others on a flange situated above the spur driving wheel. Referring to the drawing, *C* is the disc valve having duplicate

admission and exhaust port openings, *R R*, which coincide with two pairs of portways, *T T* and *N N*, in the cylinder cover during each half revolution of the valve. There are thus duplicate admission and exhaust inlet and outlet branch facets, *A A* and *X X*; the valve stem is hollow and carried up through a bearing neck in the cylinder cover, where a spur-wheel, *S*, partly supported in an independent bearing is keyed to the valve stem, *D*, by a sliding feather fit, thus permitting the valve to be held up by the spring *E*, and is thus relieved of the weight of the driving wheel. In the top of the valve stem *D* there is a gland packed intake for the circulating water, which enters by the regulating tap shown by way of the inner tube, which extends to nearly the bottom of the valve; the water there occupies the space in the hollow disc not taken up by the two port openings, *R R*, and returns up the stem *D* and by a tube forming a watertight fit to the outlet *W*. The cylinders of this engine are arranged in pairs, the valves being driven by a vertical shaft passing up between them and geared to the driving wheels of both valves; thus in the 4-cylinder engine there are two vertical shafts directly geared from the crankshaft by mitre wheels arranged between the two pairs of cranks. In order to further reduce pressure on the valve face, recesses *H* are provided which are open to the cylinder pressure, thereby causing the valve and cover faces to wear more evenly and to maintain a more perfect gas-tight fit.

The use of a disc-distributing valve in this manner is by no means new, having been anticipated by Lenoir in one design of compression gas engine made by the Reading Iron Works; a disc valve has also been used by Atkinson and others, who found a tendency for the valve to wear away more rapidly towards the periphery than near the centre.

Cylindrical rotary-valves have met with more success, the usual method of using them being to hold the valve up to its seat by a back-bearing cover, as in the case of reciprocating slide-valves. In this form, however, they were never used in engines of more than 10 h.-p., and more often in quite small engines—for example, the "Crossley" and "Premier" domestic gas engines. The "Wilcox" cylindrical valve, shown by Fig. 31, is arranged right in the combustion chamber, and revolves between two covers through which are carried two bearing arm extensions, thus relieving the valve from a too heavy pressure on to its seat. This valve is double ported, and revolves half a turn for each cycle. There is only one pair of portways in the valve seat, consequently the area of port opening is not more than one-ninth the piston area,

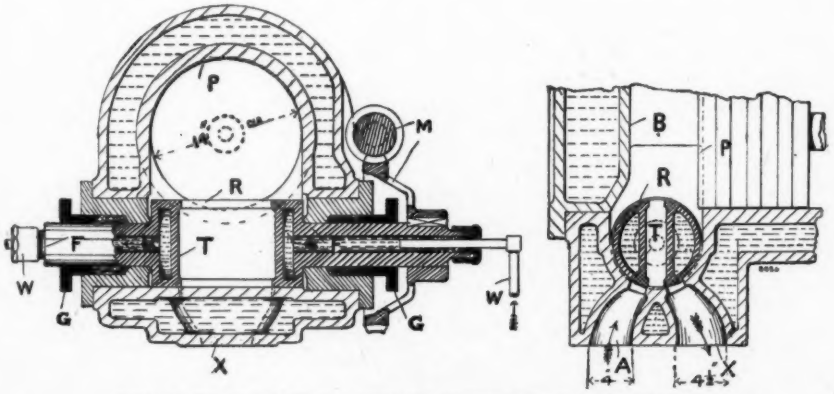


FIG. 31.—ROTARY CYLINDRICAL VALVE FOR ADMISSION AND EXHAUST (WILCOX).

although a larger diameter of valve is used. The section (Fig. 31) is taken from a double-acting horizontal 4-cycle gas engine of American construction, in which illustration *A* and *X* are the admission and exhaust portways, which are formed fan-shape to communicate with the long port opening *T* in the valve *R;* the valve is cast with arms *F F*, one of which carries the worm driving wheel *M;* the valve is cast hollow for the circulation of cooling water, which enters at *W* by a pipe at one end and leaves by a corresponding outlet at the other end, each pipe being made a water-tight fit by the union nut stuffing-boxes shown. The two valve arms are also provided with gland-packed gas-tight boxes *G* in their bearings.

This form of valve, if made of hardened material and well fitted, should wear for a considerable time without giving trouble, but it seems probable that as the valve wears down on its seat that the bearings in the covers will require renewing, unless some provision is made for adjustment of the bearings. Its advantage is its extreme simplicity and adaptability for expansion. The valve, being water-cooled and free to expand endways, can adapt itself to its seat on the bottom of the combustion-chamber provided the side bearing covers are arranged for adjustment in a vertical direction.

The ordinary rotative plug valve has received much attention at the hands of designers, but, excepting in the balanced self-adjusting form shown by Figs. 32 and 33, has not been very widely used. It is true that plug valves have been used just for the admission of explosive mixture and to time the opening to an ignition-tube, as in the case of the "Clerk" and "Niel" engines, for instance; these, however, have been only comparatively small engines, no attempt being made to balance the valves against the pressure of the cylinder explosions. In the improved balanced form of plug-valve illustrated, the valve is hollow, or rather cast with three chambers, a central double-ported exhaust chamber communicating with an exhaust outlet at one end and two D-shaped admission-chambers, one on either side, and provided each with a port opening, arranged to communicate with an inlet chamber at the other end. The valve is given approximately an 8 per cent. taper, and is held up to its seat by a small plunger open to the pressure in the cylinder; thus the valve is given practically a floating fit.

In sizes with cylinders larger than 15 ins. to 16 ins. diameter the valve is water cooled at the exhaust end, the admission end being kept cool by the ingoing mixture, which effectually insulates the exhaust central chamber walls from contact with the periphery. Valves of this construction have been in successful use for more than ten years, and exhibit but slight signs of wear; in ordinary use valves of this kind are found to wear endways about one-fortieth or so of its mean diameter in a year's everyday work, allowance being given for an end adjustment of one-fifth its diameter. The valve is more often than not capable of outwearing any other part of the engine, its rotation being only one-fourth the speed of the crankshaft. In practice no attempt is made to lubricate the valve other than at the bearing at the driving end, the surface receiving the carbonised lubricant from the cylinder is found after years' use to be dead smooth and very hard.

In vertical engines this valve has been used between two cylinders, the ports in the seat being arranged in opposite pairs and communicating with the two cylinders; the valve thus can distribute both for admission and exhaust for two cylinders, and even has been used for three, but in this case the unavoidable length of the portways is a drawback. When arranged vertically it is necessary to use a counterpoise weight to balance the valve against its own weight, a plunger being used, as when arranged horizontally to oppose the force of the explosion, pressure tending to drive the valve out of its seat.

Referring to the sections (Figs. 32 and 33) which illustrate a 20 in. double-

acting horizontal cylinder, the explosive mixture enters direct from the governor throttle at *A*, which communicates with the two *D* passages *N N*; the mixture hence enters the explosion end of the cylinder *B* by the two oppositely-arranged portways and openings *U U*; the valve continuing to revolve as the motor piston completes its suction stroke, then cuts off the supply, and, further continuing its rotation, will open to the exhaust and release the pressure towards the end of the working stroke, when the port chamber *T* will be in communication with both the portways *U U*, the complete cycle occupying the time for the valve to turn a half revolution.

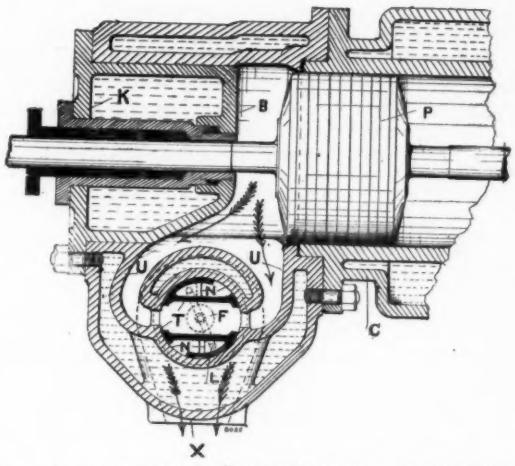


FIG. 32.—CROSS SECTION OF "BUTLER" COMBINED ADMISSION AND EXHAUST PLUG VALVE FOR 20-INCH DOUBLE-ACTING ENGINE.

In order to retain the valve in working position up to its seat, a plunger or piston *F* is placed in communication with the motor cylinder by means of the pipe *E*, a continuation of the plunger *M* being carried through a packing-box to the water case at the end of the valve cover, where it is provided with inlet and outlet service pipes *W*. The water enters the valve by a tube with a fork extension *L* for supplying the cooling circulation right to the ends of the jacket chambers, and returns along the hollow stem to the outlet at *W*. A weak spring is enclosed in the cover at the exhaust end of the valve, and is of just sufficient tension to keep the valve from moving endways out of its seat or from oscillating during the admission and exhaust strokes, when there is no effective pressure to bear against the plunger *F*. The area of this compensator or balancing piston is approximately equal to the difference of cross-sectional area of the valve exposed to the port openings *U U*, *i.e.*, it is equal to the differences in valve diameter at the two ends of the port openings.

At the driving end the worm-wheel *R* is journalled on the cover, which serves also as a bearing for the valve shaft extension, which is free to move endways in the driving-wheel *R*. In some cases

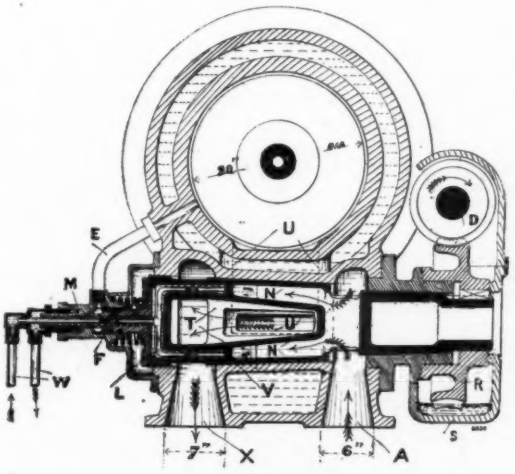


FIG. 33.—LONGITUDINAL SECTION OF BALANCED WATER-COOLED PLUG VALVE FOR DOUBLE-ACTING ENGINE.

liners are provided to facilitate boring and the cutting of the port openings *U U*, but as the use of a liner involves a greater thickness of metal between the wearing surface of the valve and the cooling surface, the best results are obtained when the combustion-chamber is bored truly to receive the valve direct.

As in the working of an explosion engine, in order to obtain the best results, so much depends on the gas-tightness and timing of the valves, and in multiple-cylinder and double-acting engines, especially where the number of cams required for operating the various forms of lift valves needs the utmost care in their setting to obtain strictly accurate results, any improvement making for an enhanced efficiency of the valves and mechanism used for the distribution of the actuating fluid demands the most careful consideration.

It will have been noted in the foregoing that the majority of the valves devised for the improved working of the explosion engine may be classified as lift or poppet valves in various forms and combinations, and that one feature in their working is particularly distinguishable, *i.e.*, their entire dependency on spring action for closing; and it may be stated at this point that this drawback, more than any other incident in their working, has been the principal cause for inducing so many attempts towards the development of some form of valve having an entirely positive action.

All admission valves which are dependent on the suction of the motor piston for their opening are for the most part fitted with either compression or extension spiral springs coiled in cylindrical form. Some advantage in this connection can be obtained by the use of a conical or volute spring, as such a spring of a given length opposes a lower ratio of increasing resistance as the valve is being pulled off its seat. In the Silverman and Remington methods of suspending the inlet valve, so as to neutralise this tendency as far as possible, the valve stem, instead of being connected directly on to the end of spiral or volute spring, is provided with a small bell-crank lever; in the case of the first-named, the long arm of this crank is connected to an extension spring in such a manner that as the valve opens there results a decreasing rather than increasing ratio of resistance opposed to the lift of the valve. In the Remington device two bell-crank levers are used; one pair of arms of these levers is connected directly to the valve stem, and the other two arms are connected together in such a manner that the two levers can be held together so as to hold the valve on its seat by one extension spring, the two bell-cranks being fulcrumed on supporting links pivoted to the valve-case. The particular effect in the manner of the opening and closing of the valve in this way is similar, if not identical, to the Silverman device, the valve in both cases having opposed to it a lower ratio of increasing resistance, which can be proportioned to prevent all chattering or vibrating action during the suction stroke of the motor piston.

To obtain this effect in larger engines inlet valves are used sometimes, which are provided with dash-pots and other means to steady their opening movement, the tendency to oscillate being caused by the increasing resistance opposed to the opening by the spring, and also to some extent this action is aggravated by a certain degree of adhesion of the valve on its seat.

In the "Humphries" admission valve for large engines there is a separate cylinder and controlling piston, which is provided with mechanically-opened smaller valves for actuating in this manner the main admission valve by air pressure, this arrangement having been designed for use with the inlet valve of the "Körting" type of two-cycle engine with the object of being thus able to impart to the valve a more rapid and silent action.

For closing exhaust-valves much stiffer springs are required, the valves in this case having to be held down on their seats gas-tight during the admission strokes, when the suction effect in the cylinder may attain to anything up

to 7 lbs. or 8 lbs. per square inch according to the degree of throttling action given to the supply of explosive mixture. It is for this reason that balanced valves have a further preponderating advantage in thus not being subjected to the suction tendency to lift them off their seats and thus to result in the leakage of exhaust-gases to the cylinder during the admission stroke. Unbalanced exhaust poppet valves, therefore, for this reason, oppose an additional resistance to being opened on account of the higher pressure spring required plus the pressure of the gases in the cylinder, and accordingly subject the operating cam shaft to a very severe strain.

In order to compensate for this effect to some extent in large engines provided with one unbalanced exhaust-valve, an increased purchase action is given to the valve at the commencement of the lift, as in the case of the "Cockerill" engine. In Continental practice exhaust-valve levers are also provided with a roller purchase action for the purpose of lessening the shock to the operating mechanism; toggle levers and other compensating gear are also sometimes used, but a great deal can be done by suitably shaping the disposition and proportion of the lever, roller, and cam.

In these articles an endeavour has been made by the author to introduce for comparison practically every variety of distributing valve adapted for the working of all forms of gas, oil, or spirit engines, large or small, their respective merits in each individual case having been considered by a careful and most impartial treatment; and, as a further aid to any attempts towards the future improvement of the internal combustion engine, all the sectional illustrations used have been prepared from actual working drawings wherever practicable.

Practical Hints on Pumps.

By P. BJORLING.

WHEN purchasing a pump there are many things that must be considered, as, for instance, the quantity of liquid to be pumped, its nature and chemical properties, whether the liquid is clean or contaminated with sand, mud, or any other impurities of this class that will wear a pump piston or plunger very quickly.

For these reasons, to decide what class of pump and of what material the pump should be made, also what class of valves and what material they should be made of, are the most important considerations. These and other matters it is our intention to dwell upon in this short article.

The relative values or, rather, the advantages and disadvantages of the piston and the plunger pumps, have already been discussed fully in the *Engineering Review*.

If the quantity to be pumped is great, the height to which it has to be delivered and the height of suction is small, centrifugal pumps are very advantageous, especially if the water is impregnated with foreign matter. They are also very good and frequently used for pumping auriferous sand in gold mining. If properly constructed they can pass small pieces of wood, weeds, &c., without doing any harm to the pump, and are easily cleaned out if any large obstruction should take place, which cannot pass through the vanes of the impeller.

If the pump is employed for raising tar and ammoniacal liquor, all the parts coming in contact with the liquid must be made of cast-iron.

For sewage, as a rule, cast-iron should be exclusively used.

Pumps for vinegar of ordinary strength should be made of gun-metal or phosphor bronze, but if the vinegar is extra strong antimony should be used as an alloy with lead.

For strong acid, single-acting plunger pumps made of earthenware, stoneware, glass, gutta-percha, or cast-iron lined with gutta-percha are necessary. For these pumps the stuffing-boxes should be packed and all the joints made with asbestos. Glass pumps are sometimes used; the barrel is made of the best glass, bored and polished true and parallel; the top and bottom chambers being made of lead, or an alloy of lead and antimony. The glass pumps are also to be recommended for alkaline fluids.

Acids are sometimes raised by means of double-acting air-pumps. The acid is gravitated into vessels, technically called acid egges; when the egges are full, the delivery pipe of the air compressor pump is set in communication with it and the pump forces air into the same, and by that means elevates the acid to the tank or cistern without passing through the pump.

For beer, bucket pumps are generally employed, made of gun metal, or semi-rotary or wing pumps, made of the same class of material.

Double-acting piston pumps made of cast-iron are recommended for benzole, benzine and creosote, but the working barrels are usually made of gun-metal for small pumps, and cast-iron lined with gun metal for large pumps, and the pump-rods of Delta metal.

Treble-barrel bucket pumps are used for bleaching mills, made of cast-iron, with the barrels lined with gun-metal.

For dyeworks double-acting piston pumps should be used, the material of which they are made depending upon the chemical properties of the dye to be pumped.

For milk of lime any class of pump

will do, but they should be made entirely of gun-metal.

Any class of pump will do for naphtha if they are made of cast-iron throughout.

For vegetable oil the pump should be made of gun-metal, but for petroleum and similar mineral oils all must be made of cast-iron.

For salt water, any type of pump; all parts must be made of gun-metal. A good mixture consists of:—

Copper	... ...	8 per cent.
Zinc	... ...	2 ,,
Tin	... ...	10 ,,

Sugar solution and treacle can be pumped with double-acting piston pumps, single, double, and treble-barrel plunger pumps, all parts made of gun-metal. Semi-rotary or wing pumps are also used for this purpose with great advantage. The same classes of pumps, made of the same material, are recommended for wine.

Pumps used for hydrochloric acid must be made of Hargreave and Robinson's patent white metal or an alloy consisting of:—

Lead...	... ...	1 lb.
Tin ...	... ...	1 ounce.
Antimony	... ...	1 ,,

but these three metals must be quickly and intimately mixed just before casting.

We must now turn our attention to the valves most suitable for the different classes of liquid, fluid, or semi-fluid to be pumped; generally speaking, if metal valves are used, they should be of the same metal as the pump.

The valves are the most important part of a pump; let the design be good in all the other respects, the performance of the pump will be seriously affected if the valves are of an unsuitable type, or bad in workmanship and design. A large portion of the power lost in a pump is greatly due to these defects; it is, therefore, very important that great care should be taken in designing to obviate them, and a careful choice of the class of valve that is most suitable for the work to be performed.

It is as useless to advocate the universal adoption of one particular class as to advocate one class of pump for all purposes, as the conditions under which they are employed are so numerous that a single type would fail to fulfil all the requirements.

Valves to be employed for raising ammoniacal liquor should be made of cast-iron of the mitre type or mechanically moved piston valves. Sometimes mechanically moved slide valves are used, although they are not as good as piston valves. This class of valve and material is also to be recommended for anthracine oil.

For benzine, benzole and bilge water, gun-metal mitre valves are the best, or, if the height of lift is small, "Dermatine" or gun-metal balls may be used with advantage.

For breweries any class of valve will do, but clack valves are very sluggish in their action, consequently allowing a great amount of slip. Whichever type is employed they should be made of gun-metal.

When creosote is pumped, cast malleable clack or mitre valves should be adopted.

For gelatinous fluids, not containing acids, gun-metal clack valves are to be used; but if there is acid present a large proportion of lead should be used in the gun-metal alloy.

If glutinous fluids of thick consistency are to be pumped, mechanically moved piston valves, or clack valves made of cast iron, or ball valves, will be found to answer remarkably well; but if the fluid is thin, cast malleable mitre valves will do.

For hot water, gun-metal valves of the mitre type are best; for warm water india-rubber disc valves, specially prepared and vulcanised fibre manufactured for the purpose. Dermatine is also very good.

Gun-metal clack valves or ball valves should be used for milk of lime.

For naphtha, cast iron or cast malleable iron mitre valves, especially the latter, are good.

Vegetable oil pumps should be fitted with mitre or clack valves made of gun-metal.

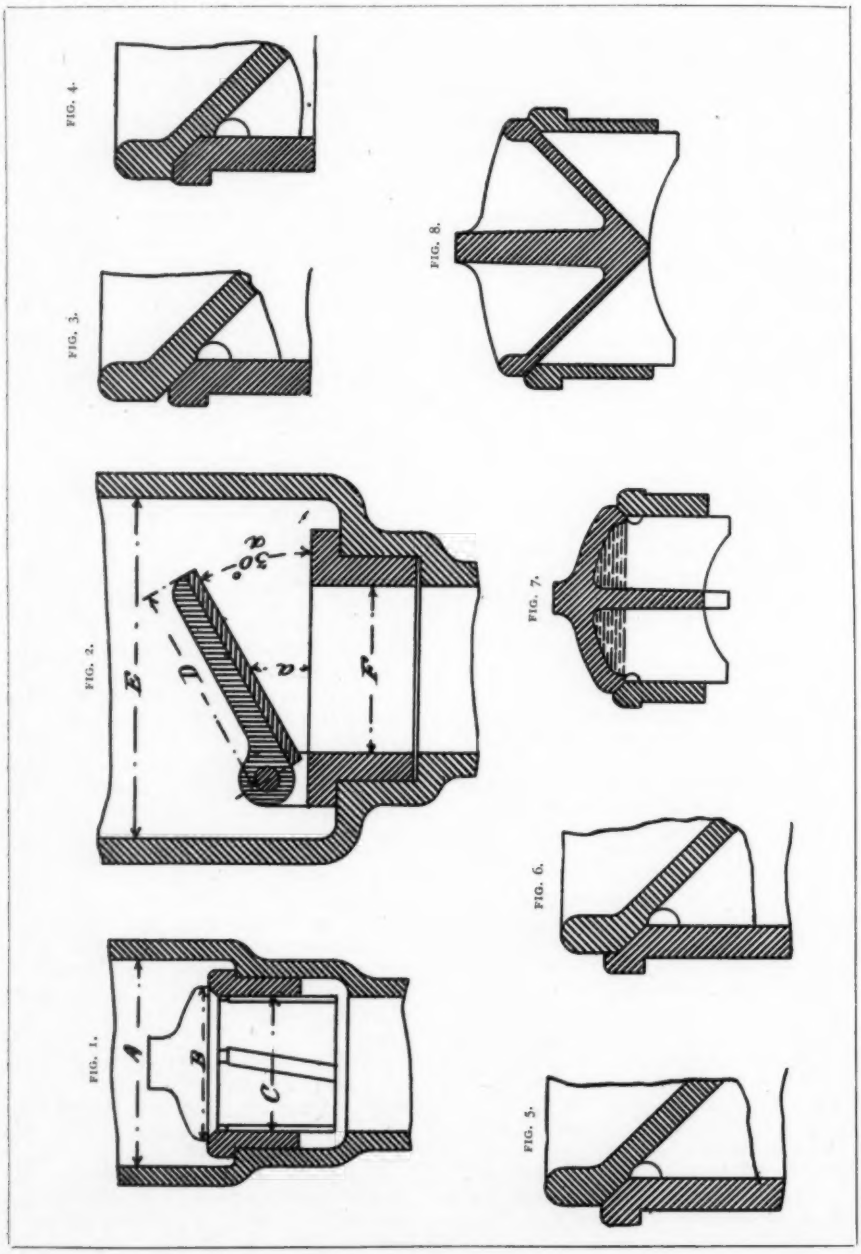


FIG. 1.
A
B
C
FIG. 2.
E
D
A
30°
α
α
F
FIG. 3.
FIG. 4.
FIG. 5.
FIG. 6.
FIG. 7.
FIG. 8.

For paper pulp cast iron ball valves are the best and cheapest. India-rubber lip valves have been recommended, but they become very expensive as they wear out very quickly.

Clack valves or mechanically moved piston valves made of gun-metal are most suitable for treacle and sugar solution.

For tan liquor, gun-metal bell or clack valves; but the alloy must possess a great portion of lead, on account of the tannic acid present in the oak-bark contained in the liquor.

Tar pumps are best fitted with mechanically moved piston valves, or mitre valves made of cast malleable iron. The bell valves have also been found very serviceable for tar.

Clack valves are mostly used in mine pumps on account of their simplicity and ease in repairing.

SOME IMPORTANT FACTS ABOUT PUMP VALVES.

If the beats of the valves are of metal, they must both be made of the same class, whether it is a pure metal or an alloy, or else an electrolytic action will take place which will eat away the metal.

Valves with perpendicular lift should have all the ribs and guides placed at an incline from the perpendicular, that the water in passing through the water-way may give the valve a gradual circular motion, which tends to keep the beat perfect and prevents the formation of grooves, because the valve will not beat on the same place on the seat twice in succession. An inclination of one half-inch in six inches is enough for small valves. Large valves should have, according to modern Cornish practice, an inclination of two and one-half inches in one foot.

When perpendicular lift valves are guided by means of a spindle or spill, care should be taken to cast the spindle longer and downwards to ensure it being quite solid, and the porous end turned off.

In designing metal valves it is of the greatest importance that the metal should be a uniform thickness through out, or, in cooling after casting, the metal wlll draw, because the thin metal will cool before the thick part. We have frequently seen the guides or wings on mitre valves of the mushroom type, by the jarring in working, fall away from the top disc of the valve, through faulty castings produced by unevenness of metal.

A very common error in designing valve boxes is that they are too small in diameter. The area of the valve box should be equal to the area of the top plate of the valve plus the area of the waterway through the valve seat; that is, the annular space round the valve should be equal to the area of the waterway. Referring to Fig. 1, the area of A should equal the area of B plus the area of C.

In the case of valve boxes for clack valves, the circumstances are different, because they do not deliver all round, as is the case with mitre and other perpendicular lift valves. Strictly, the waterway ought to be eccentric with the valve box, the shortest distance being on the hinged side of the valve. Fig. 2 illustrates a valve box fitted with a clack valve. The diameter of the valve box should be calculated by the formula given below, because the horizontal projection of the valve is an ellipse of the diameters D and D cos. a, also the surface of the same; wherefore we get:

$$\frac{D^2 \cos a}{4} \times 3{\cdot}1416$$

$$\frac{E^2 \times 3{\cdot}1416}{4} = \frac{D^2 \cos a}{4} 3{\cdot}1416 + \frac{F\, 3{\cdot}1416}{4}$$

and thereby

$$E = D \cos a + F^2;$$

but as a rule the diameter of the valve box is calculated in the same manner as for perpendicular lift valves.

The diameter of the top plate of the valves should never be made larger than the largest diameter of the mitre in the seat. The reason why is best illustrated by the annexed Figs. 3, 4, 5 and 6.

Fig. 3 illustrates the section of part of the valve and seat as they are usually made, that is, having the external diameter of the valve plate larger than the diameter of the top of the mitre. Fig. 4 shows the shape of the beat when it has been worn, making both a flat and mitre beat combined. If we now look at Fig. 5, in which is depicted the valve as it should be, the diameter of the top plate being made equal to the top of the mitre, and Fig. 6 illustrates how it wears, showing that it does not matter how far it wears down in the seat, it will still remain only a mitre beat. It is of great importance to guard against a lodge in the valves, just as it is in a pump and valve boxes, especially the delivery valves. What we mean is best illustrated in Fig. 7, where the air lodge is indicated by the dotted lines. For the above reason the valve illustrated in Fig. 8 is the best; besides, it is guiding the water in the proper direction instead of allowing it to strike against a flat surface.

India-rubber disc valves should have an easy fit in the centre spindle, not nipped tight between the seat and the guard, and be allowed a small vertical lift, or else they will have the tendency to crack round the centre hole, especially if they are nipped very tight and allowed to bend against a conical guard or one made with a very small radius. The guard should be of a large diameter, so as not to allow the disc to turn round the periphery of the guard, which causes the rubber to crack all round in a very short time.

There is one peculiarity with some india-rubber disc valves which we believe is very little known, but deserves to be carefully noticed, that is, that if one of the faces of the disc is placed towards the grid-seat, the disc becomes slightly convex on the bottom face and a great amount of slip takes place; but if the disc is turned round it becomes all right for work.

When soft material is used for the beats of the valves all corners should be well rounded so as not to present any cutting edges, as, for instance, the openings in the grid seat for india-rubber disc valves.

The openings in the grid seats should be made to an angle of 45 degrees, so as to give a partial rotating motion to the disc. This greatly increases the life of the india-rubber.

SOME IMPORTANT FACTS ABOUT PUMPS.

There is a prevalent idea amongst some of the pump makers that the cheapest made patterns are the cheapest. The writer's experience is that it is the dearest. We have often found instances when two shillings more spent on a pattern have saved as much as ten shillings in the foundry. Again, we have seen the efficiency of a pump spoilt by a few shillings spent in pattern making. For instance, a division in the pump, for the sake of cheapness, being made straight instead of an easy curve, which will guide the flow of the water in the proper direction, increases the friction of the water.

The position of the valve boxes is very important. They should always be so arranged that there is no possibility for the air to lodge in any part.

In quick-running pumps all passages should be large. The valves should also be large with a small lift, if the valves are automatically moved; but if they are partially actuated, as in the "Riedler" pumps, the lift can be made any height. There is a great deal less friction in one large valve than in a number of small valves.

The object of pressure air vessels is to correct the intermittent discharge of the liquid into a continuous flow in order to prevent the concussion to the machinery caused by the force required to overcome the inertia of the liquid, and to economise the power of the motive force by keeping the liquid in constant motion, thereby decreasing the speed of the liquid when the pump pipes are smaller than the working barrel.

The most important matter regarding air vessels are the positions, the sizes and shapes. They should be placed as

near as possible to the pump, and in such a position that the air contained in the water will be able to separate from it and enter into the air vessel.

For ordinary pumps it should be three to four times the capacity of each stroke of the pump, but for comparatively heavy pressures and fire engines it ought to be double that capacity. Some makers of large waterworks pumps give the air vessel a capacity of ten times the contents of the pump or pumps, as the case may be.

The best proportion, perhaps, is to make the internal diameter of the air vessel the same as the diameter of the working barrel of the pump. This cannot always be done on account of the great height required. In such cases the height should be made as great as possible. Of course, for large pumps with a capacity of ten to one, this rule is out of the question, therefore the diameter of the air vessel must be increased. The neck or throat of the air vessel should be made long and narrow, to prevent the water in the vessel from being disturbed by the action of the pump.

Air vessels should be fitted with a set of glass water gauges and glass to indicate the height of the water level, or a pair of try cocks might be used, but the former to be preferred. Large air-vessels should be provided with a manhole for clearing out accumulated dirt or sediment, especially in sewage works.

In order that a pressure air vessel may properly fulfil and perform its necessary functions, a sufficient supply of air must be constantly stored within it, because air is subject, more or less, to absorption by water. An air vessel without means of supplying the loss occasioned is of very little use.

The suction air vessels are applied to the suction pipe or suction side of a pump, just below the suction valve, or as near as possible to it. In vertical pumps they can be made to surround the top of the suction pipe. These vessels are strongly recommended when the suction pipe is long, small in diameter, or when the pump is running at a great speed.

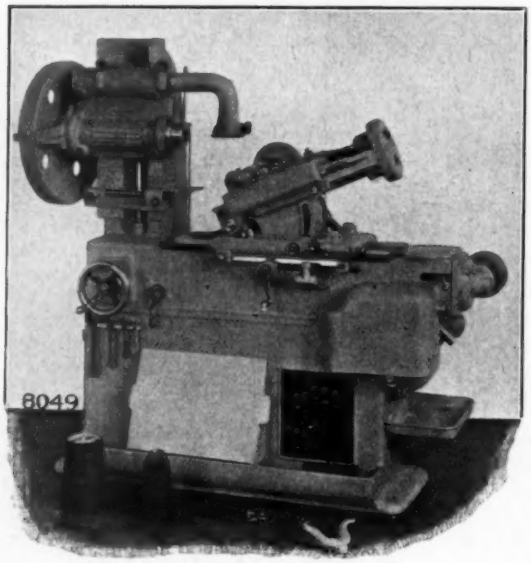
Machine Tools used in Automobile Construction.

By E. C. AMOS, M.I.Mech.E.

As was pointed out in the last article,* the growing importance of the self-propelled vehicle has had a very direct influence upon the machine tool industry. It would also be correct to say that the absence of anything like finality in motor car design is causing constant and rapid changes in machine tool requirements. It is doubtful whether, in the history of engineering, there has been placed upon the market a greater variety of machine tools (largely called into existence by the demands of the motor car builders) in so short a time as that which has elapsed since the passing of the Motor Car Act.

In the old days, if one may use such a term in regard to so modern an industry, when single or even double cylinder cars of low power were more in vogue than they are now, the machine tool outfit was of modest dimensions. To-day the 4-cylinder car is general, and

* Pages 157—160.



AUTOMATIC GEAR CUTTER FOR SPUR AND BEVEL WHEELS, BY MESSRS. BROWN AND SHARP.

the controversy which has been raging in the motor car press for some little time past would seem to indicate that the 6-cylinder car is soon likely to be in demand for the bigger powered cars at any rate. The multiplicity of cylinders has not only led to adoption of higher powers, but it has also necessitated multiplicity of parts, together with the need for greater accuracy and refinement, and hence the call for a great variety of new and, in many cases, expensive machine tools.

It is somewhat doubtful whether the enhanced price obtained for 6-cylinder cars, and which is quite out of proportion to the extra cost of manufacture over the 4-cylinder type, is likely to be sustained for very long.

It would be obviously out of place in these articles to express any opinion as to the merits of either system as compared with the other; but should the 6-cylinder type become general, the machine tool industry will benefit thereby.

With a view to standardisation it is much to be desired that, before long, we shall see an uniformity in motor car construction such as that which pertains in the cycle trade to-day.

It is yet too soon, however, to expect this; and in the meantime tool manufacturers are gradually feeling their way in regard to motor car requirements and in putting on the market new and special machines.

Notwithstanding the immense advance made by our own manufacturers in high class automatic machines, there are still a large number of imported machines to be found in most up-to-date motor works.

In the preceding article reference was made to a spur wheel gear cutter by Messrs. J. Parkinson & Son, of Shipley, which has secured for itself an excellent reputation as a well designed and accurately made machine.

Particulars will now be given of a "Brown and Sharp" automatic gear cutter for spur and bevel wheels.

These machines have long been on the market and the illustration here shown is taken from a machine of the latest type. Its capacity includes the cutting of spur and bevel gears up to 18 ins. diameter by 4 ins. face. This machine is the embodiment of all that is best in American machine tool construction, and will be found exceedingly useful for the purpose for which it is designed.

In these days of high speed steel the question of rigidity is of the greatest importance; this machine has been designed with that object in view. The spindle bearings and wearing surfaces are of ample proportions, and all cylindrical bearings are ground to standard, whilst plane bearings are ground to surface plates. The outer end of the cutter spindle has a support, fastened to

the slide, but easily removable for changing cutters. The cutter carriage is adjustable to any angle up to 90 degrees, and the cutter can be set to either side of the centre for cutting bevel gears.

The return of the cutter slide is rapid and, as it is independent, it remains constant irrespective of the speed or feed of the cutter. The work spindle is of exceptionally large diameter, and the front end has a standard taper hole to receive a face plate or other fixture to give additional support to the gear. A hole extends from bottom of the taper hole entirely through the spindle. The indexing mechanism is positive, and as it has an accelerating motion when starting and a retarding motion when nearing the end of the indexing, it operates without shock. It is driven independently at a constant speed, thus insuring rapid indexing irrespective of the speed or feed of cutter.

Adequate provision is made for protecting the working parts from dust. The chips fall directly into a pan, where they can be easily removed. The trough round the bottom of the base serves for catching lubricant and returning it to the pump. Suitable strainers separate the chips and lubricant, and provision is made for attaching a pump to the machine at any time.

The upright portion of the frame is fitted with shelves for holding the index change gears, and a recess in front of the machine is fitted in a similar way for holding the feed change gears.

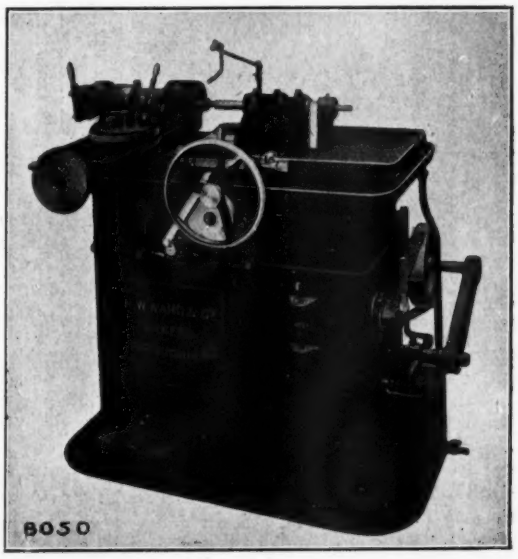
The cutter spindle is $\frac{7}{8}$ in. diameter, and has eight changes of speed. The cutter has twelve changes of feed obtained by change gears. The change gears provide for cutting all numbers of teeth from twelve to fifty, and all numbers from fifty to four hundred, excepting prime numbers and their multiples.

No part of a car is more important or likely to cause more serious trouble than the bearings. The extensive use of the ball type is now general, and many firms are devoting themselves to their manufacture exclusively. Differences of opinion still exist, however, in regard to ball bearings in the engine and other places, and a great many plain bushed bearings are found on the chassis. The little "Ward" bush grinder, which is here illustrated, is suitable for the internal grinding of parallel or taper bushes, ball races, &c.

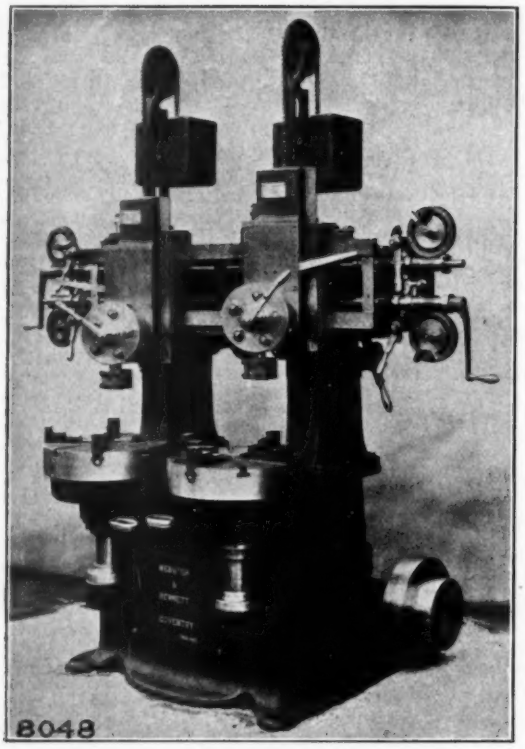
The general arrangement of the machine becomes obvious by looking at the illustration, and it will be sufficient to note the following features.

The work headstock has a cross motion by screw and handwheel, which is graduated to read in half-thousandths of an inch on the diameter of the work.

The work headstock can be swivelled through 45 degrees each way for grinding tapers. The work spindle can be swung up out of line with the grinding spindle, without disturbing any part of



BUSH GRINDER: MESSRS. H. W. WARD AND CO.



DUPLEX BORING AND TURNING MILL : MESSRS. WEBSTER AND BENNETT.

the machine, to facilitate gauging or changing the work, and can be stopped or started by foot clutch. The spindle is of hardened steel, running in adjustable gun-metal bearings, provision being made for taking up end motion. It is held in working position by a spring lock. The chuck is either a three-jaw self centreing, or an automatic draw-back collet chuck, which latter can be operated without stopping the work head.

The internal grinding head slide has hand and automatic adjustable traverse in both directions. The adjustable reversing stops are provided with a fine adjustment, and the slide will reverse to a line at both ends of its stroke.

A grinding spindle pulley is mounted in special ball bearings to relieve the spindle of all belt pull. The spindle has a tube surrounding it, and both the spindle and the tube are inde pendently adjustable in length from the head, so that the former is supported right up to the wheel. All slides are efficiently covered in all positions, and are adjustable for taking up the wear. The bed of the machine forms a water pan, an ample supply of water being provided by means of a pump driven by belt from the countershaft. The latter is carried on brackets at the back of the machine, and is driven direct from the main shaft.

The machine will grind up to 6 ins. diameter by 6 ins. long, and will take emery wheels up to 1½ ins. diameter. The internal head spindle runs at 12,000 revolutions per minute with a countershaft speed of 450 revolutions per minute. The work head spindle has a variable speed, adjusted according to requirements and ranging from 20 to 123 revolutions per minute. The machine weighs under one ton.

Messrs. Ward also make a more elaborate machine on similar lines but fully automatic and capable of face grinding in addition to the internal work. Both of these machines will be found exceedingly useful in motor car construction.

Another very useful machine is the "Webster and Bennett" 14-in. duplex vertical boring and turning mill. This type is in general use for turning and boring wheel blanks, bushes, glands, covers, &c., such as would be generally dealt with on an 8-in. lathe. It is quickly operated, the work being always in sight of the operator, and is specially adapted to be run by one man, securing the greatest possible output. When possible it is very convenient to turn the

piece on its one side on the one chuck and then turn it over and machine the other side, thus ensuring a steady stream of finished pieces.

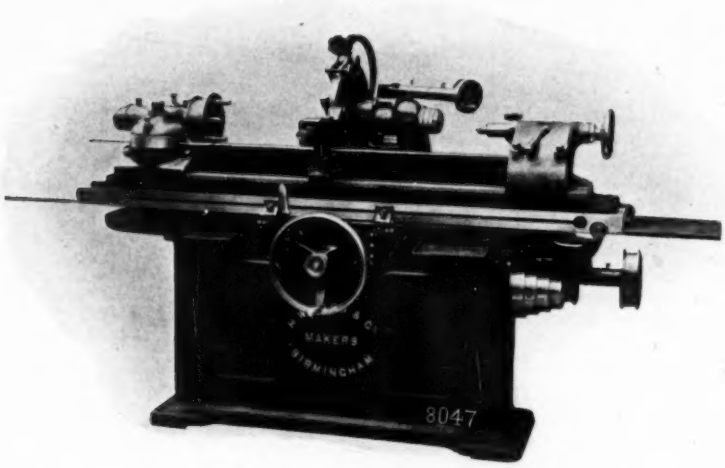
The machine is in reality two machines quite independent of each other in every particular but combined in one body. It is designed to use high-speed cutting tools and is provided with large bearings and ample bearing surfaces throughout. All feed motions are automatic and self-stopping, whilst the trip motions are exceedingly simple. The feeds are driven by wide belts, the change from roughing to finishing being made by hand levers. The driving mechanism is of hardened steel and all gears are machine-cut from the solid. The chucks are 18 ins. diameter, will surface up to 14 ins. diameter, and swing 22 ins. diameter. The machine, which will admit 18 ins. under the turret and 15 ins. under the cross side, weighs $2\frac{1}{4}$ tons. The duplex profile milling machine, by the same maker as the duplex mill just described, is a more general tool than the mill, but has a greater range of usefulness. It will be found to do good work on the edges of glands-brass or iron-brass checknuts, sleeve-cams, &c. This machine will mill its own former directly from a sample piece of work, and is also used to mill the formers required in both cam shaft profile milling and grinding machines.

Reference to these types will be made in the next article. One operator can attend to the double machine and a fine finish can be obtained on the work by allowing it to mill twice round the article.

Having regard to the large number of hardened parts in motor cars, grinding machines are largely used in their construction. Many of these requirements are met by the use of the "Ward" universal grinder which is here illustrated. This machine is designed for all kinds of cylindrical grinding within its capacity, such as shafts, spindle bushes, gauges, collars, &c., either parallel or taper.

The emery wheel spindle runs in

DUPLEX PROFILE MILLING MACHINE. MESSRS. WEBSTER AND BENNETT.



UNIVERSAL GRINDER. MESSRS. H. W. WARD & CO.

adjustable gunmetal bearings carried on a massive headstock, which swivels in a horizontal plane, the base being graduated to read in degrees. This allows of quick tapers being conveniently ground, the table remaining set for parallel or slow taper work. The emery wheel is fed on to the work by the hand wheel on the arm above the headstock.

The wheel headstock slide is completely protected from water and dust, and the wheel is surrounded by a substantial cast-iron shield with provision for supply of water while grinding.

The internal grinding head is fixed on the back of the wheel headstock after removing the wheel guard, and is brought into position by swinging the headstock completely round. To obtain the necessary increase of speed the internal spindle is driven from a pulley put on the external spindle in place of the emery wheel, which is removed by unscrewing one nut only. The drive from this pulley on to the internal spindle pulley is by means of a belt. The spindle is hardened and ground, and runs in adjustable gunmetal bearings. The work headstock swivels in a horizontal plane, the base being graduated to read in degrees. For chuck work this spindle revolves, but for plain grinding a locking pin keeps it stationary, and the work is revolved on dead centres.

The tailstock is provided with a spring barrel which allows for any expansion of the work due to heat, and ensures a uniform pressure on all work between the centres.

The work heads are adjustable along a table which swivels on a central pin, hardened and ground, and can be swivelled for grinding taper work up to 14 degs included angle or 3 ins. to the foot. This can be effected by means of a screw at the right hand end of the sliding table, which is graduated to read in degrees and inches per foot of taper, for that purpose.

The sliding table upon which the swivel table is mounted, slides in a V-groove at the back, and on a broad flat at the front. Its length and ample wearing surfaces are important factors in obtaining and maintaining accurate results.

The traverse is automatic in both directions, and can be regulated to any length of stroke required up to the maximum. There is also a fine adjustment

on the automatic reversing dogs which allow of small variations of stroke being effected while the machine is working. The table can also be traversed by hand or power to any position without affecting the setting of the dogs. An effective water pan is provided by the top of the body of the machine, and the interior of the body itself forms a convenient cupboard for accessories, &c., and is provided with shelves and two doors at the front. Two trays are fixed on the front of the machine for the reception of tools, &c. The pump is of a simple centrifugal type, and the tank forms part of the body of the machine. The machine, which is driven by a triple overhead countershaft having self-oiling bearings, will admit 42 ins. between centres and swing up to 14 ins. diameter. The automatic traverse is 42 ins. and will take wheels 12 ins. by $\frac{1}{2}$ in. and 13 ins. by $\frac{3}{4}$ in. It weighs about $1\frac{1}{2}$ tons.

The Limits of Thermal Efficiency in Internal Combustion Engines.*

By DUGALD CLERK, M.Inst.C.E.

THE Institution of Civil Engineers Committee on the Standards of Efficiency of Internal Combustion Engines, among their recommendations as to the standard engine of comparision for internal combustion motors, recommended that for the purpose of the standard, air—assumed to be a perfect gas having a value of $\gamma = 1{\cdot}4$—should be taken as the working fluid. For the ordinary four-stroke cycle engine, the formula giving the efficiency then is

$$\eta = 1 - \left(\frac{1}{r}\right)^{0{\cdot}4};$$

where $\left(\frac{1}{r}\right)$ is the ratio of the minimum volume to maximum volume. The committee were satisfied that with good engines, giving their best economy, the actual efficiency divided by the ideal efficiency determined by this standard could be expressed by a ratio which varied between 0·5 and 0·7. This was deduced from separate tests made by Professor Meyer and Professor Burstall. Professor Burstall's tests also showed how inefficient design would decrease the ratio, as in some of his tests means involving greatly increased cooling surfaces were employed to increase the compression, and were found to considerably diminish the ratio. These tests showed further how too high flame-temperature also decreased the ratio. The committee required, however, further knowledge as to the effect of the dimensions of the engine on the ratio, and accordingly they made tests on three engines of 5 ins., 9 ins., and 14 ins. diameter cylinders respectively, giving 6, 24, and 60 I.H.P. In these engines, taking the mechanical efficiency to be 88 per cent., and calculating the I.H.P. from B.H.P., they found that the efficiency ratios were 0·61, ·65, and 0·69 in the three engines. The tests showed, therefore, that by bearing in mind the slight changes in the ratio due to difference in dimensions, a close approximation to the best indicated efficiency to be expected from a given compression could be obtained by the use of a factor varying between 0·60 and 0·70, according to the dimensions of the engine. The tests also showed very clearly the small increase in economy of large engines in comparison with small ones, there being only 12 per cent. increase between 6 h.-p. and 60 h.-p. The possible efficiency with the actual fluid used in the engine was known to be less than that given by the air standard. The committee considered that a definitely known standard from which the actual efficiency could be deduced by using a multiplier found experimentally, allowing for the imperfections of the engine as well as for variations in the properties of the working fluid, should be adopted until the properties of the working fluid were accurately known. The author has examined the results of the test made by the committee, and has made some further experiments on the large engine used in the

* Abstract of Paper read before the Institution of Civil Engineers, February 26th.

test, with a view to finding the true heat distribution in the engine.

The balance-sheet given by the committee is as follows :—

	L	R	X
Exhaust waste	35·3	40·0	39·5
Jacket waste	23·5	29·3	25·0
Radiation	7·6	10·0	7·3
B.H.P.	26·7	28·3	29·8
	93·1	107·6	101·6

In obtaining this balance-sheet the exhaust waste was determined by calorimeter, jacket waste measured, and the radiation includes friction of the working parts. The B.H.P. was determined by rope brake. In order to reason as regards properties of the working fluid, it is necessary to know the I.H.P., the loss of heat during explosion and expansion, and the heat in the gases at the end of expansion. These quantities are not given in the ordinary balance-sheet, as determined above. In the ordinary test the jacket loss is always over-estimated, because some heat which ought to go to the exhaust calorimeter flows to the water-jacket after the opening of the exhaust valve and all through the exhaust stroke of the engine. The piston friction also will appear in the water-jacket. The author has therefore attempted to adjust the balance-sheet from data given in the committee's report. Taking the mechanical efficiencies for the three engines, L, R, and X, as 0·84, 0·85, and 0·86, the friction percentage of total heat is 5·1, 5, and 4·9 respectively. Deducting this from the jacket waste, corrected values for heat to water-jacket, 21, 26·8, and 22·6 per cent. are obtained. Using these values, and reducing to percentage, assuming that the error in total heat is not in the I.H.P. item, a new balance-sheet is obtained:—

	L	R	X
Exhaust waste	41·1	37·1	39·9
Jacket waste, True radiation	27·1	29·6	25·4
I.H.P.	31·8	33·3	34·7
	100·0	100·0	100·0

The ideal efficiencies in these engines are practically the same, and assuming that one-third of the heat going to the engine is converted to work, and that the heat loss occurs near the beginning of the stroke, the difference between the jacket plus radiation losses in any two engines should be three times the difference between the I.H.P.'s. In the L and X engines this is found to be exactly the case. The jacket waste in the L engine is evidently too low, and on the above considerations should be 34·1. This value of jacket waste for the L engine will give an exhaust waste of 34·1, which is practically the same as that determined by calorimeter. It appears, therefore, that in the L engine some heat which should have appeared in the water-jacket has been lost. This corrected balance-sheet is probably more accurate than that obtained in the test; but there is still some heat found in the water-jacket which should be in the exhaust. The experiments give no means of determining this amount. The balance-sheet, however, gives a method of calculating the maximum possible efficiency of the actual fluid. Adding exhaust waste to I.H.P., and dividing I.H.P. by the sum, possible efficiences for the three engines of 0·482, 0·473, and 0·465 are obtained. In obtaining these efficiency values, however, it has been assumed that the heat is lost at the beginning of the stroke, and therefore the values are not accurate. If the distribution of heat loss were known, the true adiabatic could be constructed and correct results obtained.

To check the results, indicator diagrams which give the correct mean pressure have been studied. From the composition of the exhaust gases and the charge temperature, the weight of the charge is found to be 0·14 lb. From the diagram, the temperature drop from the end of expansion to charge temperature is 1,745° F. The specific heat of the gases by weight, assumed constant, is 0·185. From these values, obtained from the numbers given in the Committee's report, it appears that 43 per cent. of all the heat of the combustible gases is accounted for in the exhaust. This gives a balance-sheet for the X engine :—

	Per cent.
Exhaust waste	43·0
Jacket waste and radiation	22·3
I.H.P.	34·7

The exhaust waste here would obviously be greater if specific heat increases with temperature. From this balance-sheet, calculated as before, an efficiency of 0·447 is obtained; with air, the efficiency would be 0·49. These considerations show the difficulty in using the actual fluid as a standard. In spite of the great labour expended on the experiments, only a rough approximation to the true heat distribution can be arrived at.

In 1884 the author made experiments on cooling after explosion in a closed vessel. Many other investigators have since done similar work, but cooling of a cylinder having a moving piston had never been investigated. The author made further

experiments, and determined the cooling in the X engine. The engine was run at normal speed, and when a charge had been drawn in, the rollers actuating the inlet and exhaust valves were slipped, so that the valves remained shut. The explosion then took place, and the gases instead of being discharged were alternately compressed and expanded. An indicator card gives a cooling curve, showing temperature fall during successive revolutions of the engine. From these cards the mean apparent specific heat of the gases in the cylinder has been deduced, the gases being practically the same composition as those in the Committee trials. The values given increase with increase of temperature, and have been called apparent specific heat values, because certain facts discovered are inconsistent with the change being entirely specific heat change. Calculations assuming these numbers to be the true specific heats are, however, very nearly accurate. From the cooling curves and specific heat values so determined a balance-sheet has been obtained for the X engine as follows:—

	Per cent.
Heat flow during explosion and expansion	16·1
Heat contained in gases at end of expansion ...	49·3
Indicated work	34·6

Comparing this with that found by the Committee, it is seen that the indicated work is the same in both. There is, however, less heat flow during expansion, and more heat in the gases at exhaust. This shows that about 21 per cent. of the heat in the gases at the end of expansion goes to the water-jacket during the opening of exhaust valve and exhaust stroke. This is considered a more accurate balance-sheet than has yet been obtained. Calculating the ideal efficiency as before, the value 41 per cent. is obtained. From the values of specific heat given, the adiabatic may be calculated, from which the ideal efficiency is found to be 39·5 per cent., showing that the actual engine has converted 88 per cent. of the heat which it possibly could convert into indicated work. The new method has been checked by a test of a small Stockport engine in the author's laboratory, which give similar results to those given by the X engine.

Tables have been calculated showing the ideal efficiencies for different compressions using the specific heat values given, and show that roughly the air standard is 20 per cent. too high, and that if gamma be taken 1·285 for the explosion line, and 1·37 for the compression line, the change of specific heat between 1,700° C. and 1,000° C. commonly used in practice is too small to produce much error. More investigation is, however, required before even the apparent specific heat values can be accurately known for the various mixtures used in internal-combustion motors.

Much has been recently done, including experiments by Professor Hopkinson, Messrs. Bairstow and Alexander, and Professor Burstall; but until further knowledge is obtained, the air standard, as defined by the Committee, gives the best basis for comparing the performances of different engines.

The appendixes show the method of calculating the suction temperature, charge temperature, exhaust temperature and charge weight, and also method of calculating the adiabatic and efficiency for varying specific heats.

Flame the Working Fluid in Gas and Petrol Engines.*

Although great progress has been made in the practical control and utilisation of flame and gaseous explosions, for the purposes of producing motive power, little is as yet known as to the actual properties of the flameworking fluid so utilised. In this branch of work science so far has made but little progress, and our knowledge of the properties of air and other gases at high temperatures is of a somewhat fragmentary nature. Science still requires to investigate the properties of gases at high temperatures in order to fill the gap in our knowledge at the upper end of the scale, which Sir James Dewar has so ably filled at the lower end of the temperature scale. For the present, therefore, it is not possible to formulate an accurate theory of the internal combustion motor. The subject is a difficult one, and involves not only the statical properties of these gases, but it requires a knowledge of the conditions and rate of chemical combinations occurring in minute fractions of a second, and the conditions of the dissociation of compounds at high temperatures under varying conditions of temperature and pressure. Our knowledge, for example, of the dissociation curves

* This paper is also by Mr. Dugald Clerk, it being the abstract of a lecture delivered by him before the Royal Institution.

proper to steam or carbonic acid is in the vague qualitative state. It is known that under certain circumstances some dissociation occurs; but no quantitative knowledge exists as to the amount of dissociation under any given conditions of temperature pressure, either alone or in mixture with other gases. Notwithstanding our present ignorance on this subject, many distinguished investigators have given it some attention.

To enable some investigation, however, to be made on different engine cycles, it appeared desirable to consider the gas engine as an air engine pure and simple, operated with air of constant specific heat, the air being a perfect gas and the chemical action being assumed as merely a means of heating the air through the desired temperature range. Calculating on this simplified theory, it became evident that the efficiency to be obtained in an air engine without heat losses was mainly dependent upon compression. Working out this theory showed that while the utmost that could be theoretically expected from a non-compression engine of the Lenoir type was 22 per cent. compression supplied means of getting theoretical efficiencies of as high as 60 per cent., with practical ranges of compression. Considering, then, gas and petrol engines as air engines, the theory is very simple.

The air standard has proved its utility as a guide to the engineer for twenty-five years now, and in a recent report of a committee appointed by the Institution of Civil Engineers on the Standards of Efficiency in Internal Combustion Engines, this standard has been definitely adopted as the official standard, after exhaustive tests of engines of different sizes. This simplified theory of the internal combustion motor has been most useful in pointing out the way to better efficiencies, and with its use, internal combustion motor efficiencies have risen from 16 per cent. in 1882 to a maximum of 37 per cent. in 1906. To enable further progress to be made, however, it is now necessary to know more of the actual properties of the working fluid. Unfortunately no method of investigation so far supplied was able to determine those properties. During the past two years, however, considerable progress has been made in the invention and development of new means of studying the actual working fluid within the gas engine cylinder, and the gases composing it outside the cylinder in separate vessels. In the early experiments made by the author, showing the rising and falling curves for gaseous mixtures, and in subsequent experiments made by Oliver in America, and by Messrs. Bairstow and Alexander in this country, the knowledge acquired of the rising and falling curves was only in strictness applicable to the behaviour of highly-heated gases in a closed vessel. No means of obtaining a cooling curve in an engine cylinder had been proposed.

At the beginning of 1905 the author designed a new method, and made a considerable number of experiments on a 50 h.-p. gas engine. Such engines give indicator diagrams resembling the constant volume diagram. These diagrams give information as to the time of ignition, the work done, and the compression and expansion lines followed by the charges within the cylinder. Such diagrams, however, do not give any information as to the rate of heat loss through the sides of the cylinder, or the specific heat of the high temperature charge undergoing expansion. By modifying the action of the engine, however, it is possible to get information of this nature. By altering the valve arrangements of the engine, so that when desired both inlet charge valve and exhaust valve can be held closed, the author was able to get diagrams from which a cooling curve could be calculated.

In this method no gases are allowed to exhaust from the cylinder. The piston accordingly compresses the whole contents into the compression space, and the temperature which has fallen by expansion rises by compression. A point is touched on a vertical line from the end of the card. On expanding, a line below the first compression line is traced, then another compression line is obtained, and so on, a series of compression and expansion lines are obtained, each terminating under compression at certain specific points.

In this way a cooling curve is obtained which shows the real temperature drop upon the expanding and compressing lines. From this curve, by somewhat troublesome calculations, the mean apparent specific heat of the charge can be obtained for each expanding line. A curve of specific heats so obtained was shown.

These numbers give a very fair indication of the heat loss incurred in the cylinder, and the cooling curves show that for the whole stroke the mean temperature of the whole enclosing walls is about 70° C., when the water jacket is cold, and about 20° C., when the water jacket is hot; but for the inner part of the stroke, the first three-tenths of the stroke, the mean temperature is much higher—170° C., when cold, and 400° C., when hot.

This method of investigation gives a more accurate knowledge of the properties of the

working fluid, so far as the thermodynamics of the engine are concerned, and it enables us to make an entire heat balance-sheet from this diagram only. The author has calculated full-load diagrams taken from the engine by this method, and accounted for 105 thermal units, when the calorimeter showed 106 thermal units to be present. The method appears capable of very considerable accuracy.

Professor Hopkinson has attacked the problem of heat loss to the closed vessel by another method, using a calorimeter by which the heat leaving the hot gases at any time is measured electrically, while at the same time the pressure is indicated. This arrangement promises to give important information as to the rate of loss in gaseous explosions, from which observations some deductions may be drawn as to the specific heat, and as to the time of termination of combustion.

The author is continuing investigations on various sizes of engines with a new form of optical indicator. An indicator card taken with this instrument was shown. The appearance of this indicator card is most interesting. There is slight discontinuity in the rising line, and just as maximum pressure is approached, the indicator begins to oscillate rapidly through a small distance. These oscillations continue all down the explosion stroke, and die out gradually, and do not terminate until the end of the compression stroke. The period of the oscillations is about 600 per second, the amplitude gradually decreases, until it has practically ceased at the end of the first compression.

The period of the indicator is about 200 to the second, so far as ordinary piston displacement is concerned. From this it follows that considerable pressure disturbances within the cylinder must have occasioned the oscillation. In this particular engine, the explosion was always accompanied by a peculiar whistling sound, which seems to start just about the time the diagrams show the beginning of the oscillations; that is, immediately after ignition. It is somewhat difficult to account for this peculiar action, but it appears to have some connection with the discontinuous nature of combustion of a mixture of inflammable gas or vapour with air. This was illustrated by an experiment in which inflammable mixture was ignited at the open end of a long tube. The flame travels back the tube, accompanying at first by a low roaring sound, which increases in intensity as the end of the tube is reached, terminating in a loud snap. When this occurs, the flame flashes back to the tube again, and there is obvious oscillation of some kind proceeding. It is not known why the mixture flame burns in this way, but this particular roaring or whistling seems to occur only when combustion is going on, and is noticed in all pressure flames in the open air. It appears highly probable, then, that whenever this oscillation goes on, combustion is still proceeding.

Experiments have also been made by Messrs. Holbein & Austin on the specific heat of air and carbonic acid by an entirely different method, and there is reason to hope now that as a result of experiments which are now progressing in this country and on the Continent, the whole question will be cleared up in the next few years in a satisfactory manner.

As one who has given thirty years' study to the practical and scientific problems involved in this matter, it is exceedingly gratifying to find a great and increasing interest in the subject which will lead to the complete investigation of the complex properties of the working fluid.

Suggested Method for Experiments on the Wind Resistance of Ships.*

By F. H. ALEXANDER.

OUR knowledge of the reduction of a vessel's speed owing to the resistance caused by wind pressures upon her exposed structure is in a very rudimentary state. My object in this paper is to suggest a comparatively inexpensive method whereby some experiments might be carried out to increase that knowledge.

The apparatus needed consists of three parts: (1) a floating framework, (2) the ship structure to be tested, (3) the recording gear. Figs. 1 to 4 show the arrangements of the floating framework, intended to be moored in an open sheet of water free from currents. This framework consists of a principal member, *A*; transverse members, *BB* and *CC*, diagonally stayed to *A*, at its forward end; three watertight trimming boxes, *D*; breakwater logs at front and sides, *E*; and breakwater sparring from *BB* to *CC*. The object of the breakwaters

* Paper read before the North-east Coast Institution of Engineers and Shipbuilders.

FIG. 1.—ELEVATION OF FLOATING FRAME.

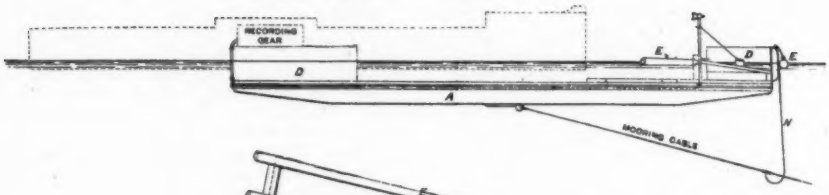
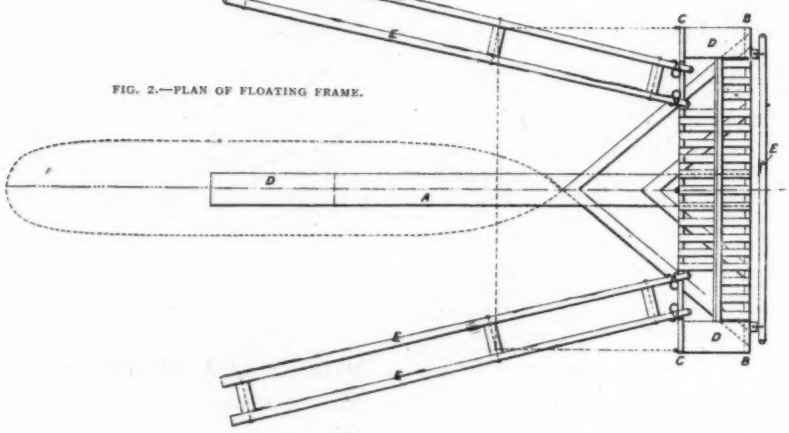


FIG. 2.—PLAN OF FLOATING FRAME.



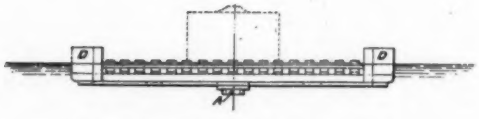


FIG. 3.—ELEVATION OF B.B. LOOKING AFT.

FIG. 4.—ELEVATION OF C.C. LOOKING FORWARD.

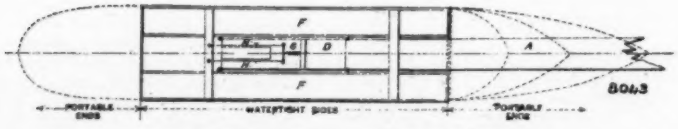


FIG. 5.—PLAN SHOWING WATERTIGHT PART OF VESSEL.

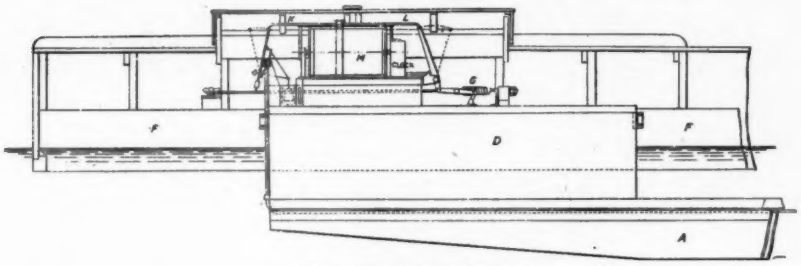


FIG. 6.—RECORDING GEAR ELEVATOR.

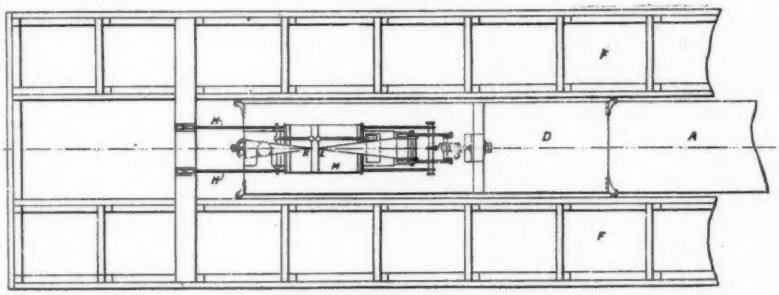


FIG. 7.—RECORDING GEAR PLAN.

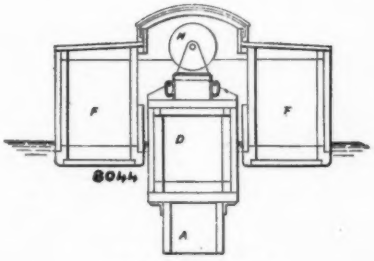


FIG. 8.—CROSS-SECTION.

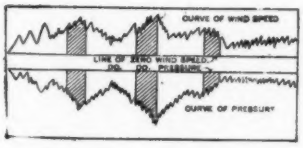


FIG. 9.—DIAGRAM OF RECORDS (IMAGINARY).

is to give smooth water about the tested structure. Fig. 5 shows a plan of the water-tight portion of this ship structure. It consists of two pontoons, *F*, separated so as to clear the trimming box on *A* (Fig. 1), and free to move aft under wind pressure against the tension of the dynamometer spring, *G*, which is attached to *D*, and extended by the connections *H*, secured to the ship. These side pontoons are decked over, and otherwise connected, and form the midship, permanent, and buoyant part of the ship. Portable non-watertight ends, erections, and other parts of any suitable construction can be added or removed as desired.

Fig. 6 shows, on an enlarged scale, an elevation of the dynamometer and recording gear, and of the sliding hatches covering these parts.

Fig. 7 is a plan and Fig. 8 a cross section showing views of some of the same items.

The recording apparatus consists of a Lander's wind-speed recorder, *K*, and a resistance or pressure recorder, *L*, which indicates the extension of the spring, *G*.

The records are traced upon a sheet of paper secured on the time-revolving drum, *M*. Upon the diagrams so obtained, fixed tracers indicate the lines of zero wind pressure and speed, and, if desired, a time record can also be traced in the usual manner. Provision is made (1) to support the tracing links if, in extreme cases, they are moved beyond the limits of the drum, (2) to remove the tracers and links, and the drum when it is desired to adjust them.

It is possible that it would be preferable to elongate the member, *A*, so that it projected behind the vsssel, and to erect upon its after end the necessary recording gear quite clear of the vessel herself, so that there might be no interference with the erections amidships in getting at the records. This, however, would involve extra cost in the framework.

The necessary adjustments of drums, tracers, and clockwork having been made, the apparatus is left to itself to record the variations of wind speed and pressure. The floating frame and the ship swing head to wind, no matter what the direction of the wind may be. When the paper is removed from the drum the diagrams traced upon it may be analysed at leisure. Fig. 9 shows an imaginary specimen of the lines obtained, and it is proposed to determine the mean pressure-effect corresponding to a mean wind speed, by taking any portions of the figures, such as those shaded, integrating (by planimeter or otherwise) and determining the mean heights in the usual manner, the scales for speed and pressure being known.

Strictly speaking, a correction should be made to the readings given by the speed recording tracer. This correction varies with the ratio of the arc to the chord of the angle turned through by *K*. It would only amount to half of 1 per cent. at the extreme extension, and it has not been thought advisable to attempt to correct it by introducing mechanism which might in itself cause greater error. The correction can be mathematically determined if such accuracy is considered advisable. The correction is not involved in the usual method of applying Lander's instrument, because the tracer in that case describes arcs of circles and not straight lines as in the application here proposed.

It is not lost sight of that, unless prevented, the drum would revolve even when no wind was blowing or was too light to give records of any practical value; hence a pawl attachment is made to stop the clockwork unless the pressure exceeds a certain value.

It is hoped that the use of this method would enable us to obtain information about the following and other points:—

(1) The law of variation of pressure with wind speed upon such structures.

(2) The variations of pressure at a given wind speed:—

(*a*) Upon full bow forms as compared with fine ones.

(*b*) Upon flat ended as compared with rounded erections.

(*c*) Upon "stepped-back" tiers of erections as compared with those whose fronts are in a vertical plane.

(*d*) Upon various arrangements of deck houses, funnels, masts, rigging, and other wind-catching details.

As it is possible that the resistances in some cases would be increased when the vessel is not directly head-on to the wind, but at an angle to it, the bridle, *N* (Fig. 1), can be used to slew the floating framework and the vessel to the desired angle. The recording apparatus will then indicate the fore and aft component of the pressure, and the true wind speed.

The value of obtaining a knowledge of the wind resistance of ships lies in the possibility that there may be cases where, without prohibitive cost, modifications in the above water design may greatly reduce the resistance, especially in strong head winds. It may be remarked that this is of special importance in vessels of relatively low power, whose speeds when in ballast condition are sometimes reduced almost to zero.

Laboratory experiments with planes exposed in steady air currents must, of course, be made in order to determine the laws of distribution of pressure over such simple surfaces, but it is reasonable to argue that a test such as is herein proposed is more in accordance with the conditions a ship has to meet. Nature's winds are not usually steady air currents, and the many-surfaced exposed parts of a ship are very different from simple plans.

It will be observed that, with the view of reducing cost, the watertight parts of the apparatus have been kept as small as possible. The vessel shown in the figures is about thirty to fifty feet long.

MOTOR ENGINEERING.

By ROBT. E. PHILLIPS, A.M.Inst.C.E., M.I.Mech.E.

The Renard Road Train.

This novel form of "self-propelling" road train, although well known in France—the country of its origin—is little known in this country. A syndicate has, however, now been formed to exploit it, and as the manufacture has been undertaken by the Daimler Company, of Coventry, it will certainly not fail for want of proper manufacture, though before it can be commercially used in this country an alteration will require to be made in the Motor Car Acts. Demonstrations of its practical working have recently been made in this country, and it appears to have so many possibilities that it will be a pity if the disabilities standing in the way of its use are not removed.

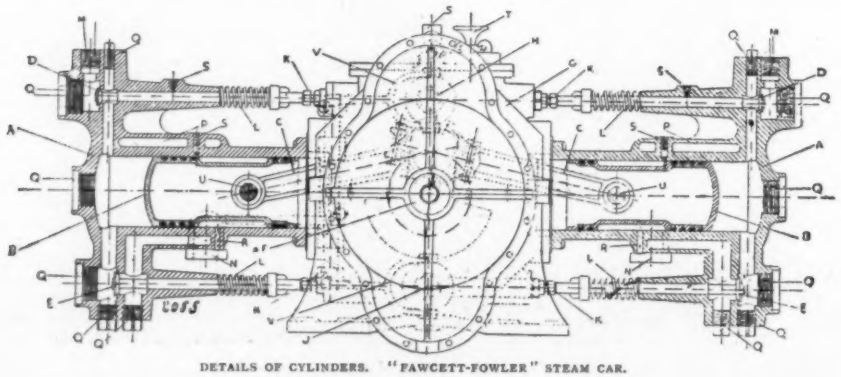
The train consists of a power wagon and as many passenger or freight wagons as are required. In the demonstration train the power wagon carries a four-cylinder internal combustion engine of 75 h.-p. The other wagons have three pairs of wheels; the centre pair are rigid with respect to the frame, and are the driving wheels, and the two end pairs are capable of being deflected, and are the steering wheels. The driving wheels of each passenger or freight wagon are driven by the motor in the power wagon by a series of cardan shafts which, with connecting shafts which are telescopic, form a continuous propeller shaft. One of the cardan shafts of each wagon drives a differential counter-shaft located in advance of the driving wheels through a two-speed

THE RENARD ROAD TRAIN.

gear, the said counter-shaft being connected with the driving wheels by chain gearing. To overcome the slipping of the driving wheels, which would take place when a train of several wagons was being steered from a curve of a large radius to one of a smaller radius, each of the wheels is fitted with a compensating device in the form of a spring drive. The total weight of each wagon is distributed over the six wheels by means of levers which connect the ends of the central springs to the inner ends of the end springs, which allows the driving wheels to rise and fall independently of the other wheels. The steering wheels are coupled together and can be controlled from both ends of the train. When running the train backwards the wagon is steered from the rear, for which purpose special mechanism is provided. The total tare weight of the train, which consists of one power wagon and three passenger or freight wagons, is just under 11 tons, the tare weight of the power wagon is just over 3 tons, and the weight is equally distributed over the two axles. By keeping the power wagon separate from the other wagons the latter can be left at their destination to be unloaded and loaded while the power wagon can be doing useful work with another lot of wagons. This application of the multiple unit system applied to road vehicles has so many good points in its favour that we await with interest its development.

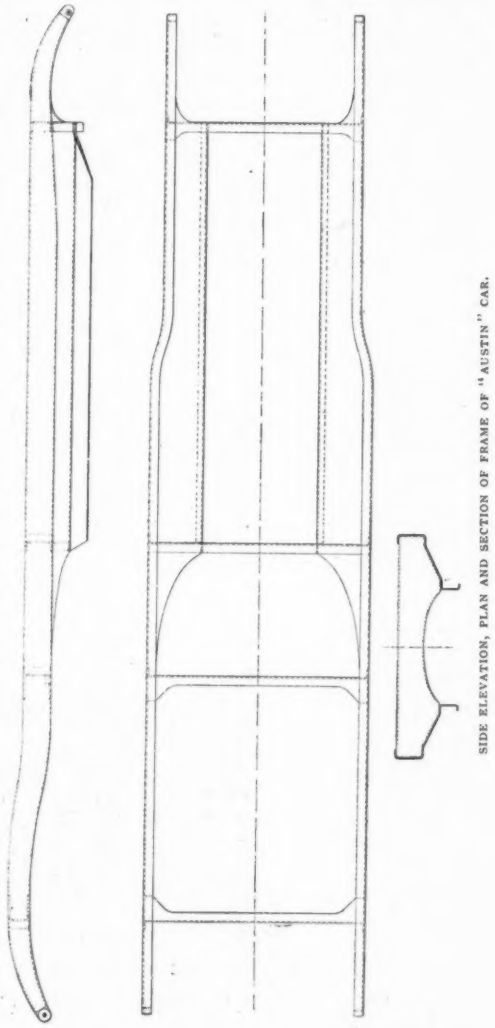
A New Steam Car.

The number of makers of steam cars for pleasure purposes is so limited that the advent of a new one is always a matter for comment. At the recent Motor Show at Liverpool a new steam car, named the "Fawcett - Fowler," manufactured by Messrs. Fawcett, Preston & Co., Ltd., of Liverpool, was exhibited for the first time; it is fitted with a generator and engine of a special type, which make it possible in practice to use highly superheated steam at a high pressure. The engine, which is classified as 20—25 h.-p., has four single-acting cylinders arranged horizontally in opposite pairs with the crank-shaft lying longitudinally to the frame. The crank-shaft has only two throws, which are at 90 degrees to one another, the connecting rods of the opposite cylinders being coupled to one crank-pin. In the sectional elevation, shown in the accompanying illustration, only two of the cylinders are shown, the other two being directly behind them. The cylinders, which are open-ended, are fitted with poppet valves, and have integral jackets through which the exhaust steam passes. The pistons, which are one of the novel features, are circumferentially recessed about the centre of their lengths and are fitted with rings at each end. The length of each recess is such that throughout the travel of the piston it is always in communication with the atmosphere through a vent hole in the wall of the cylinder, so that any steam passing the rings in the back of the piston is at once reduced to atmospheric pressure. The object of this construction is to provide an escape for the steam which invariably leaks past pistons of the usual construction when highly superheated steam is used, and which steam accumulates in the crank-chamber and blows out the lubricating oil, which not only interferes with the splash system of lubrication but causes considerable waste. The valves, which are of the poppet type, are operated by cams, the



DETAILS OF CYLINDERS. "FAWCETT-FOWLER" STEAM CAR.

shafts carrying the inlet or admission valves being located above the crank-shaft and that for the exhaust valves below the said shaft. The cams operating the admission valves are so constructed and arranged that any desired degree of "cut off" can be obtained. No change-speed gear is employed, but a clutch is fitted between the engine and the propeller shaft for driving-in traffic when close attention has to be paid to the steering of the car. The generator is of the flash type, the volume of steam generated depending on the amount of water passed through the boiler, which is regulated by a by-pass valve. For starting up an auxiliary hand-pump is employed to force water through the coils of the generator, which are heated before pumping is commenced. The feed water is delivered from the pumps through an exhaust steam heater of the indirect contact type. The exhaust steam after leaving the cylinders passes through the jackets thereof, thence through the water heater to the condenser, which is located at the front of the car and is provided with a fan, and from the condenser it gravitates to the feed water or supply tank. The paraffin, which is the fuel employed, is delivered from the fuel tank to the burner under pressure derived from an air pump driven by the engine. The vaporiser consists of a hot tube through which the fuel passes, and being vaporised passes into a mixing chamber in the form of paraffin vapour, where it takes up a sufficient volume of air to produce a completely combustible mixture. The quantity of paraffin vapour admitted to the mixing chamber is regulated by a small lever on the steering wheel. As the burner is completely enclosed in a metallic casing from which the outer air is excluded, there is no possibility of its efficiency being interfered with whatever may be the atmospheric conditions.



SIDE ELEVATION, PLAN AND SECTION OF FRAME OF "AUSTIN" CAR.

The "Austin" Cars.

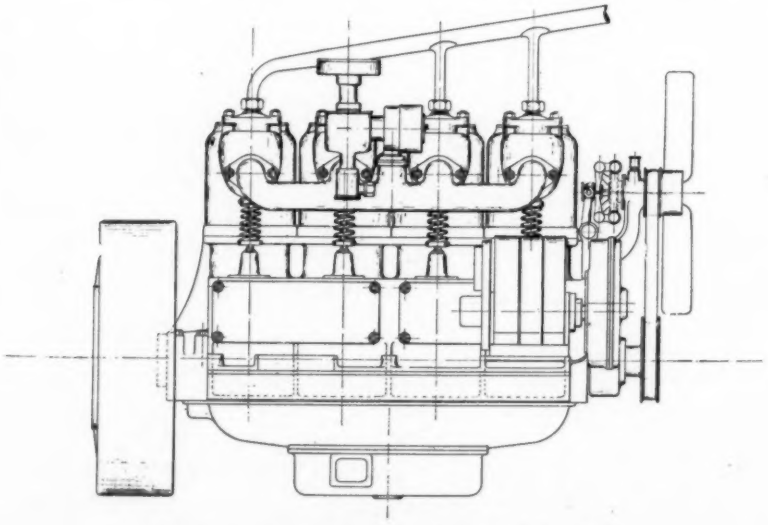
Through the courtesy of Mr. Herbert Austin, the founder of the Austin Motor Co., Ltd., and the responsible head of the Wolseley Tool and Motor Car Co., Ltd., during the years that the motor car department was built up and brought to the prominent position it now occupies in the automobile trade, we are able to supplement our description of the "Austin" cars.

The "Austin" cars are of two powers; the larger is fitted with a 25—30 h.-p. engine and has either a chain or "live axle"

drive, and the smaller is fitted with an 18—24 h.-p. engine and has a "live axle" drive. The principal dimensions of the two cars are as follows:—18—24 h.-p. car: wheel base 9 ft., track 4 ft. 7 ins., width over all 5 ft. 4 ins., length over all 12 ft. 9 ins; 25—30 h.-p. cars: wheel base 9 ft. 9 ins., track 4 ft. 7 ins., width over all 5 ft. 4 ins., length over all 13 ft. 6 ins. The frame is of pressed steel, narrowed at front end to permit of a wide lock of the steering wheels. The section is deep in centre to prevent sagging of the frame when fitted with large bodies, and is well stayed against twisting and bending strains. The sub-frame for carrying the motor and the gear box is formed in one with the side members of the main frame, both being pressed out of one piece. The steering gear is irreversible of a new and much improved design, adjustments being provided for taking up wear without dismantling any portion of the gear. The coupling bar connecting the swivel arms is placed at the rear of front axle, and all the joints are fitted with lubricators. Two external metal-to-metal shoe brakes are fitted at the rear of the gear box over the forward universal joint of propeller shaft. The drum for these brakes is automatically cooled when the foot pedal is depressed to put on the brakes, and the shoes are well ribbed to throw off the heat by radiation. The side brakes take the form of expanding shoe brakes engaging drums formed solid with rear hubs. The brakes are applied by a side lever operating through a balance gear so as to exert an equal effort on each wheel, and strong springs are employed to release the the brake shoes and hold them against stops to prevent their rattling.

The engine is of the vertical type, and has four separate cylinders of a new design, embodying the advantages of both the fixed and loose liner types. The 18—24 h.-p. engine has a bore of $4\frac{1}{8}$ ins. × 5 ins. stroke, and the 25—30 h.-p. engine has a bore of $4\frac{1}{2}$ ins. × 5 ins. stroke, the former giving 22 b.h.-p. and the latter 33 b.h.-p. at 900 revolutions. The exhaust and inlet valves and gears are fitted at opposite sides of the cylinders, and all the parts of both are interchangeable. The crank shaft is a single forging of chrome nickel steel, and is considerably larger and stronger than is generally to be found in this size of motor.

In the 25—30 h.-p. engine the cam shafts are so arranged that they can be removed without disturbing any other part of the motor, the motion of the cams being imparted to the valve through rocking levers. The lift of the inlet valves can be regulated to control the running of the motor. A very sensitive governor is fitted to the end of the fan spindle, and this controls the action of a throttle valve which is normally closed. An accelerator pedal conveniently

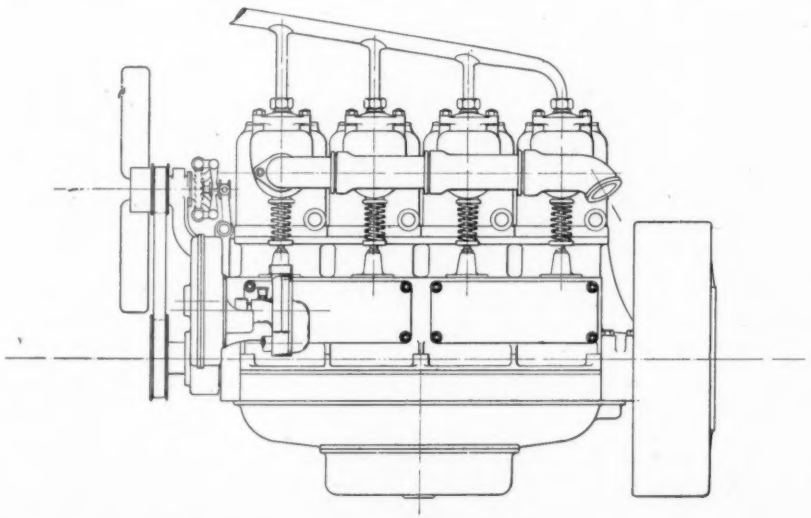


SIDE ELEVATION—ON INLET SIDE—OF 18—24 H.-P. "AUSTIN" CAR.

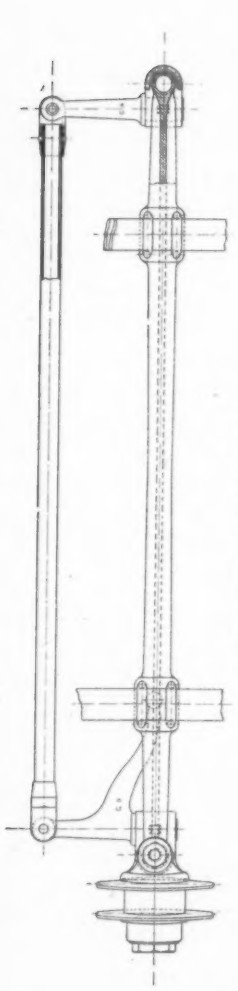
placed to the right of the brake pedal gradually cuts out the governor and opens the throttle. The point at which the governor cuts out automatically can be regulated by the lever on the steering wheel, so that it is not necessary to continually keep the accelerator pedal depressed. A lever is also fitted to the steering wheel which controls the time of ignition for both systems of ignition.

On the 18—24 h.-p. car the ignition is by a "Simms-Bosch" high-tension magneto as standard, but an auxiliary coil and accumulator apparatus can be fitted. On the 25—30 h.-p. car both ignitions are fitted. The low-tension gear is of an entirely new design and is very simple and durable. The rocking make-and-break rod has a long and substantial bearing, and is fitted in the cap over the inlet valve, which can be quickly removed for inspection. The point of ignition can be adjusted while the engine is running, and in this way a perfectly even turning effort given to the crank, which not only reduces vibration but also materially increases the maximum power of the engine. In order to overcome the tendency to emit smoke from the exhaust, which is an inherent fault in engines using splash lubrication, the connecting rods, crank and cam shafts are lubricated by a pump, which circulates oil in regulated quantities round these bearings. The pistons are lubricated separately by a pressure feed lubricator fixed to the dash. Both 18—24 h.-p. and 25—30 h.-p. cars are fitted with honeycomb radiators, the top and bottom portions of which form tanks. A fan driven by a belt from the crank-shaft is fitted to the rear side of the radiator, and the arms of the flywheel are also formed to operate as a suction fan and assist in the cooling of the engine.

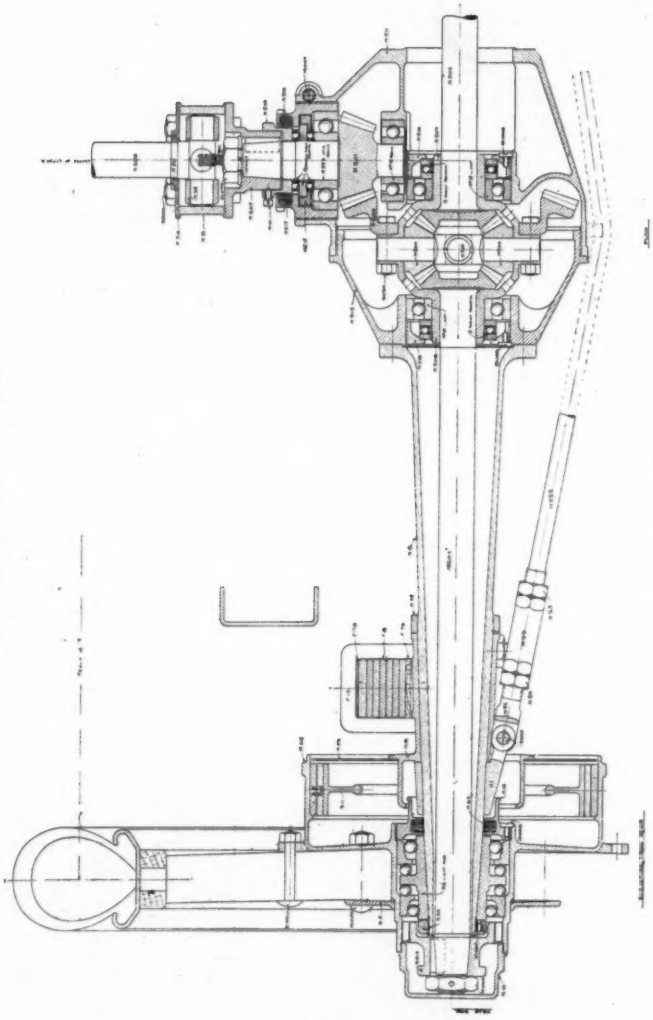
The clutch is of the multiple disc type metal-to-metal running in oil. The thrust of the spring is self-contained, so that no end pressure is put on either the engine or gear box. In the "live axle" models the centre portion of the rear axle carrying the differential gear is a steel casting, having numerous important improvements in details. The wheels run on special "Hoffmann" ball-bearings carried on solid-forged taper steel tubes projecting from the centre castings, so that the internal shafts support no weight, but merely transmit the driving effort. The differential and bevel gears and shafts are of Kayser, Ellison & Co.'s steel, case-hardened and ground true. Double-thrust ball-bearings are used to resist the driving pressures of the bevel gear. Torque rods are employed to take the driving strains, and radius rods of special construction are employed to keep the axle in alignment. In the chain-driven cars the sprockets are exceptionally large, the smallest used



SIDE ELEVATION—ON EXHAUST SIDE—OF 18—24 H.-P. "AUSTIN" CAR.



PLAN OF FRONT AXLE OF "AUSTIN" CAR.

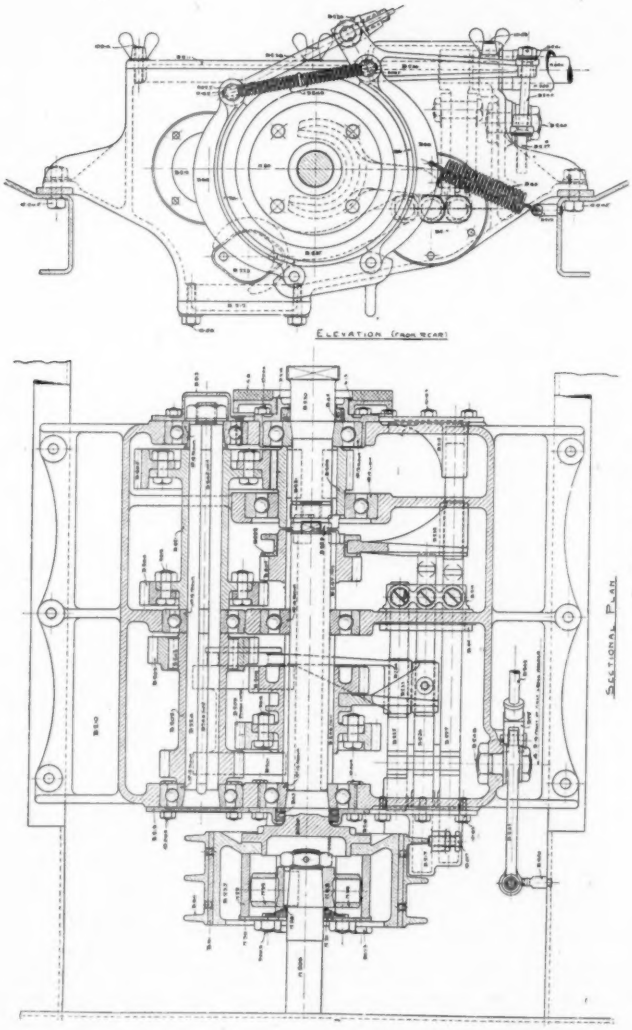


LIVE AXLE OF 18—24 H.-P. "AUSTIN" CAR.

having 25 teeth, so that the chain runs with a minimum of wear. The chain wheels are bolted to the rims of the brake drums, and can therefore be replaced or changed at will. The change-speed gear gives four changes of speed forward and one reverse. The shafts of the gear box are fitted with three ball-bearings each, so that all chance of the shafts "whipping" is avoided, thus reducing the noise from the gears to a minimum.

The gear box is in one piece, so that the grease cannot readily escape. Large inspection covers are fitted, giving ample access to all the parts. The movement of the sliding gears is effected through rods in the gear box which do not project through the ends, and as the rocking shaft moving these rods is at the top of the box no grease is able to leak out from the action of this part of the mechanism. The "gate" form

of quadrant is employed for the change-speed lever, and a safety device is provided to prevent the reverse being engaged unintentionally. The operating lever is fitted with a patent locking lever, which prevents more than one gear being engaged at a time, all the others being positively locked. The whole of the locking gear and rods are encased in the gear box, which ensures their being kept clean and well lubricated.



GEAR BOX OF 18-24 H.-P. "AUSTIN" CAR.

RAILWAY ENGINEERING NOTES.

An Audible System of Signalling on the G.W.R.

A reliable method of safely signalling trains in foggy weather has long been a desideratum, but of the numerous installations experimented with in which the object sought has been to convey a signal to the driver on the engine itself, none appear so far to have proved sufficiently satisfactory to warrant general adoption.

A system has been recently described* which would appear to possess some promising prospects. It is now undergoing test on the Fairford branch of the Great Western Railway, and has received the provisional sanction of the Board of Trade to be used as a substitute for the semaphore distant signal.

The audible signals consist of a caution whistle and a bell ring indicating clear, both of which are brought into operation by electrical means and a contacting device on the engine and line. At each signalling position a ramp e^1, consisting of a bar of T iron, is fixed between the running rails. This is supported and insulated on a wooden base and rises to a height of 4 in. above rail level, and is in electrical communication with the signal box. On the engine is a contacting shoe *d* fixed in such a position that on coming into contact with the ramp it is raised. The shoe is in mechanical contact with a switch *c*, forming part of a local circuit *b* on the engine, including a battery *a* and one of two electro-magnets *b* and *f*. The latter have their armatures yoked together, and when either of the two electro-magnets is energised the valve of the whistle is kept closed. When the shoe is in normal position the switch is kept closed, and the local circuit on the engine completed, energising the electro-magnet *b*, thus holding the compound armature and keeping the whistle valve closed. On the shoe coming into contact with the ramp, the switch is opened, breaking the engine circuit, the armature falls, and the whistle is sounded. On the engine clearing the ramp the armature is raised and the circuit once more completed.

When the line is clear it is obvious that this signal must be suppressed. This is accomplished by means of a second circuit, part of which consists of the other electro-magnet *f* and the contacting shoe *d*. The latter, it should be mentioned, is insulated from the switch *c*, operating the first circuit. The completion of the second circuit is formed by the shoe coming into contact with the ramp, which, when the line is clear, is connected by the signalman with a battery e^2 or e^3 in his cabin. The current in this circuit restrains the caution signal, which otherwise would have been given, by energising the electro-magnet *f* and holding the armature. In addition, however, to restraining the caution signal, the completion of the circuit operates an "all-right" signal consisting, as above mentioned, of the ringing of a bell. In the circuit of the electro-magnet *f*, is a winding of a polarised relay *g*, whose tongue g^1 can complete the circuit of the battery *h*, which circuit includes an electric bell *i*. When the signalman connects the positive pole of battery e^2 with the conductor e^1 the direction of the current

* The *Railway Gazette*.

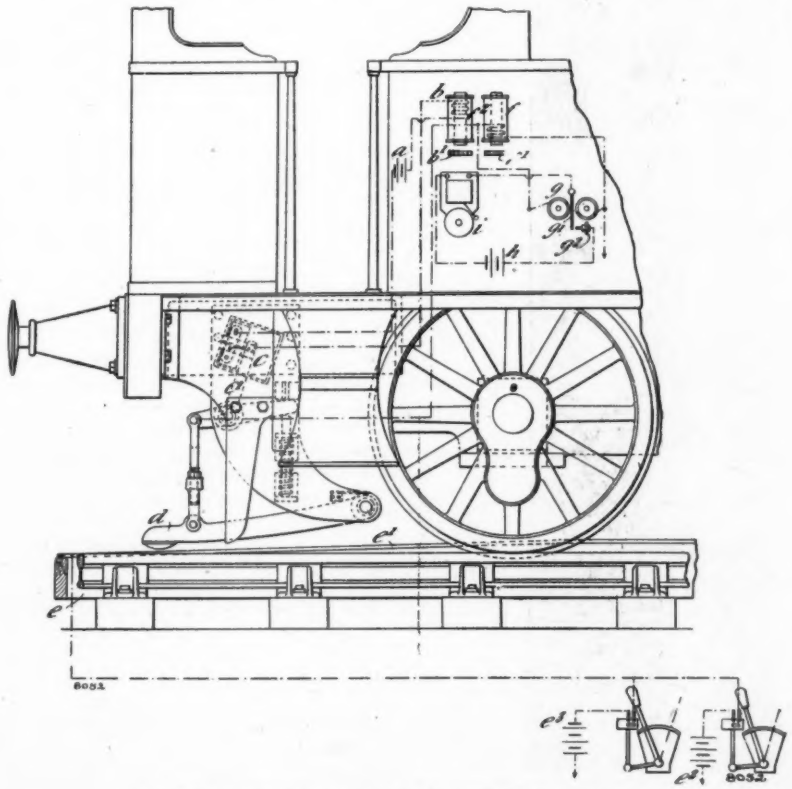
through the polarised relay g is such that the tongue g^1 turns away from the contact g^2, and the bell, which is the all-right signal, is not sounded. On the other hand, when the signalman connects the negative pole of battery e^3 with the conductor e^1 the tongue g^1 touches the contact g^2 and the bell is sounded.

The signalman has it in his power, therefore, (1) to give the danger signal by not connecting either battery with conductor e^1, (2) to restrain the danger signal without giving the all-right signal by connecting battery e^2 with the conductor e^1, or (3) to restrain the danger signal and give the all-right signal by connecting battery e^3 with conductor e^1.

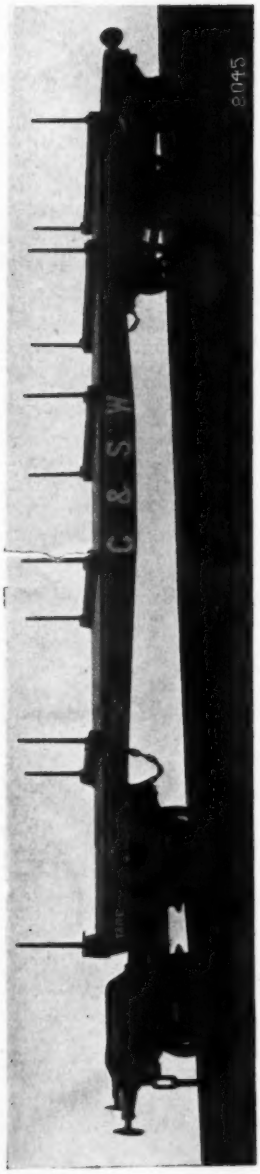
Advantage is taken of the ability to use either of these three combinations in single line working. Obviously a train passing over a length of single line will make contact with two ramps, one applying to the direction in which it is travelling and the other to trains running in the opposite direction.

As it is desirable that no signal should be given from the ramp which does not apply to the particular train, the signalman, by using combination 2, achieves this end, since the caution signal is suppressed and the bell does not ring.

A simple amplification of the system provides that a signalman cannot electrify a ramp in such a manner as to restrain the danger signal without giving



NEW SIGNALLING SYSTEM ON THE G.W.R. DETAILS OF APPARATUS.



BOGIE WAGON FOR CARRYING RAILS. GLASGOW AND S.W. RAILWAY.

the all-right signal to the train running in the direction of the other end, until all the staffs of the known staff instruments are in place, and he has received a current from the signalman at the other end.

Bogie Wagon for Carrying Rails.

Some special bogie wagons of the type illustrated in the accompanying half-tone have just been completed for the Glasgow and South Western Railway by the Leeds Forge Co., Ltd., in accordance with the requirements of Mr. J Manson, the locomotive superintendent of the Company.

These wagons have been specially designed for use in port traffic for carrying rails up to 70 ft. in length round very sharp curves. For this purpose the buffers and draw-gear are carried on the bogies instead of on the frame itself, the latter being carried by centres on the bogies as shown. The bogies are thus free to adjust themselves to any curve without the inconveniences occasioned in the older type of long-framed wagon, which tend to become locked with each other when rounding sharp curves.

There is practically no limit to the sharpness of the curve round which the new wagons will go, and they can be coupled up to the locomotive in the usual manner. As the length over buffers is 47 ft., it becomes necessary to employ dummy wagons for the carriage of rails of any length greater than this. The underframe and bogies are constructed of pressed steel frame-plates. The following are the principal dimensions:—

Length over buffers	...	47 ft.
Width over solebars	...	7 ft. 10 ins.
Centres of bogies	...	34 ft.
Wheelbase of bogies	...	5 ft. 6 ins.
Tare weight ...	...	12 tons.
Load ...	...	30 tons.

Cast Steel Locomotive Frames.

The custom of constructing the main frames for locomotives of bars of square

section is, as is well known, the prevailing practice in America. To some extent it has been followed on the continent, but the prevailing British and European practice is to use frames built up of plates.

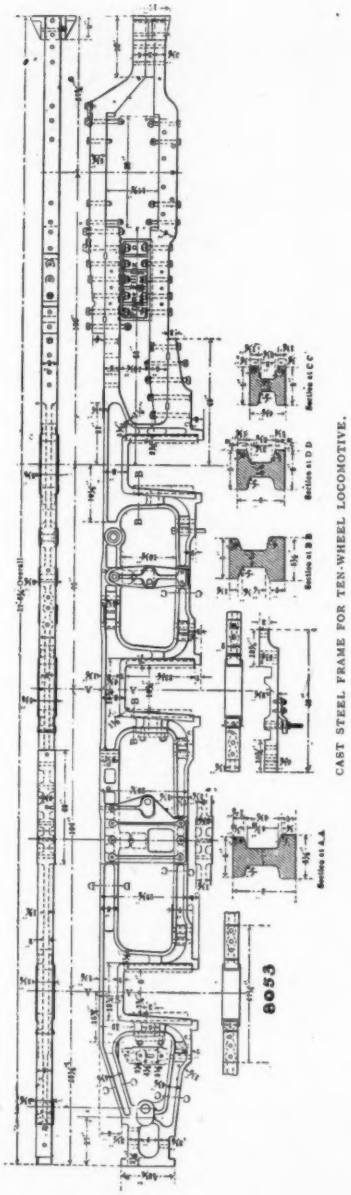
Frame failures appear to have been of fairly frequent occurrence in America, the investigation of which some time ago led to the Delaware and Hudson Company putting into service several cast steel locomotive frames having an I instead of rectangular section. According to a contemporary* the service of these frames was so satisfactory that the design is at present being very extensively used on all types of that company's engines.

An example as applied to a 10-wheel locomotive is shown in the accompanying illustration. From theoretical considerations a frame of this type, allowing the same amount of metal and the same width of frame, has been shown to be about four times as strong in the horizontal plane and a little over half as strong in the vertical plane. The subject has been further summed up as follows.†

A web section gives higher moments of inertia per unit weight than any other.

A frame casting is such that the use of coring must be eliminated, else first cost will be excessive, with possibilities of shifted cores.

The second condition reduces the number of available web sections to channel and I sections. When we consider the problem of moulding, with shrinkage effects, the latter seems decidedly the more desirable of the two. The comparative thinness of the I casting allows of a ready and careful examination by the inspector, whereas with the rectangular section, oftentimes the outer surface covers a multitude of sins discovered only when failure of a part discloses interior honeycombing. Hence, while of higher factor of safety if sound, the uncertainty of the material, for above reason, favours the I section.



CAST STEEL FRAME FOR TEN-WHEEL LOCOMOTIVE.

* The *American Engineer and Railroad Journal.*
† Proceedings of the Pacific Coast Railway Club, October, 1903.

These conclusions would appear to have been proved by the fact that the design, as pointed out above, has been continued on the Delaware and Hudson Company's engines, and, moreover, adopted on the Central Railroad of new Jersey.

The Thermo-Efficiency of Locomotives.

In dealing with this subject in a recent issue of a technical newspaper* the writer points out that as there remains very little scope for any further increase in size and weight of locomotives beyond those already reached, it is to the increased thermo-dynamic efficiency of existing types that engineers have to turn their attention. Through the hitherto comparative cheapness of two prime steam-developing elements, coal and water, this efficiency has been almost entirely overlooked, but there remains a wide field for improvement in this direction. The directions in which increased thermo-efficiency are to be sought may be summarised as follows:—

(1) By increased evaporative efficiency of the boiler, (*a*) by prevention of scaling on the heating surfaces, (*b*) by increased and adequate circulation of the whole body of water (thus reducing such scaling to a minimum), (*c*) by purification of the water (thus removing the prime cause of scaling), (*d*) by reducing to a minimum heat losses through radiation; (2) by increasing the thermo-dynamic combustible efficiency of the coal fuel so as to obtain the maximum possible heating and evaporative effects from it, with consequent reduction in consumption; (3) by increasing the thermo-dynamic efficiency of the steam developed in the boiler before it is put to work in the cylinders.

Of these the efficient thermo-combustion of coal fuel is perhaps as important as any and in the course of his examination of the question the author states his belief that the necessary economies of combustion and increased thermo-dynamic and other efficiencies can be obtained from coal fuel of any quality, whether good, bad, or indifferent, by providing in the firebox of any existing British locomotive, and with only slight and comparatively inexpensive structural alterations, such a combined steam and air draught (quite independent of the blast-pipe draught, which could be done away with or placed under complete control), as would convert the grate and fire-box into both a coal-gas and water-gas producer, to the entire elimination of imperfect combustion. All resulting wastage through the formation of smoke and ineffective gases would be eliminated, and only fully incandescent heat-gases produced, with the reduction to an absolute minimum of all wear and tear of the entire boiler and structure, and an indefinite extension of its utility and existence.

It is impossible to say much as to the feasibility of the writer's suggestion until his ideas and designs are fully made known, but there is no doubt that if increased efficiency could be obtained, with only comparatively slight and inexpensive alterations to existing locomotives, the conversion would be speedily undertaken.

* The *Times Engineering Supplement.*

LEADING ARTICLES OF THE MONTH—CURRENT EVENTS—TECHNICAL INFORMATION FROM ALL SOURCES.

Bond of Steel in Re-inforced Concrete.

A series of tests relating to re-inforced concrete have recently been carried out by Professor A. N. Talbot, of the University of Illinois, one of the objects of which was to determine the bond between concrete and steel. A summary of the results obtained is given in the following table :—

	Length encased.	Maximum Load.	Bond per sq. in.	Running friction.		Ratio of running friction to bond.
				Maximum.	Per sq. in.	
	ins.	lbs.	lbs.	lbs.	lbs.	
½-in. round	6	3,498	372	1,983	210	57.0
½-in. round	6	4,170	355	2,700	227	64.0
½-in. round	12	7,035	373	5,066	268	72.0
½-in. round	12	9,458	402	5,366	228	56.8
1-in. shafting...	6	2,570	136	1,256	67	49.2
½-in. shafting...	6	1,476	137	466	50	31.8
Mild steel, ⅞ × 1½ ins.	6	2,536	125	1,713	84	67.1
¾-in. rd. tool steel	6	2,077	147	...	...	...

* Concrete, 1:3:5½

The mixture of concrete used was 1·3·5½, and with this it was found that the results averaged 10 to 15 per cent. higher than with a mixture 1·2·4 previously tested.

Little difference was found to exist in the bond resistance per sq. in. of surface of bar in contact with the concrete whether the bar was embedded 6 ins. or 12 ins.

Other points brought out were that flat bars give a much lower resistance than round bars, and that smoothness of surface and uniformity of diameter and section have a considerable effect. This is best seen in the tests made with cold rolled shafting and tool steel. The average bond developed with these was 147 lbs. per sq. in. of contact surface, as compared with about 400 lbs. per sq. in. for ordinary plain, round, mild steel rods. Not only was there a very noticeable difference in the smoothness and finish of the surface of the rods, but the section of the cold rolled shafting and tool steel was very uniform, the diameter not varying more than 0·0001 or 0·0002 in. at ¼-in. intervals throughout the length, while mild steel rods will vary as much as 0·0015 in. It is to be expected that the smoothness and uniformity of section of drawn steel wire will operate to give low values of bond resistance, though, of course, as the section of wire is small compared with the circumference, the bond stresses developed when wire is used are relatively small.

The bars began to slip when the maximum load was reached. After slipping began, the resistance to motion was still considerable. This running friction, taken when the bar had moved about ¼-in., amounted to 54 per cent. to 72 per cent. of the bond developed in the case of mild steel bars, and to 32 per cent. to 49 per cent. in the case of the cold rolled shafting.

Explosion Phenomena of Mixtures of Gas and Air.

The results of an interesting research undertaken by Dr. Häusser with the object

of investigating the accuracy of the formulæ given by Mallard and Le Chatelier for the specific heats of gases at high temperature and at constant volumes, and to ascertain how these heats are affected by pressure, have recently been made public in a report issued by the Association of German Engineers, a lengthy abstract of which is given in the *Journal of Gas Lighting*.

A mixture of air and coal gas was selected for the experiments by reason of the great practical importance of the phenomena attending the explosion of the combustible element. Dr. Häusser's conclusions may be summed up as follows:—(1) The duration of the explosion of a mixture of coal gas and air may be said to be independent of the pressure at which it originally exists. (2) From a comparison of the periods of time occupied by the experimental explosions with those which proceed in an engine cylinder, it would appear that combustion in the cylinder is not complete at the moment when the indicator shows the maximum pressure, even if the gaseous mixture is thoroughly homogeneous; nor, if the proportion of gas present exceeds a certain amount, is it complete at the moment when the piston begins its forward stroke. In this respect the use of more rapidly-burning mixtures would be preferable. (3) In the explosive combustion of mixtures of coal gas and air, the dissociation of water vapour produces a distinct effect upon the quantity of heat liberated at all temperatures above 1750° C., but the decomposition of carbon dioxide and the formation of nitric oxide are negligible factors. (4) The increase in pressure accompanying explosion—*i.e.*, the ratio of the initial to the final pressure—is not always the same, but increases with increasing initial pressure. (5) The experiments demonstrate the accuracy of the Mallard and Le Chatelier formulæ for the specific heats of the combustion products obtained from mixtures of coal gas and air, provided the initial pressure is some 3·5 kilogrammes per square centimetre or upwards, and the temperature attained is above 1800° C. When the temperature or the pressure is lower, the final pressures calculated from the formulæ are higher than those which actually arise. (6) An application of the simple gas laws (Boyle and Gay-Lussac) to the explosive combustion of mixtures of coal gas and air, with the object of calculating the temperature of explosion from the rise in pressure, shows the specific heats of the combustion products to be a function of the pressure, decreasing as the pressure increases.

The Testing of Inflammable Gases.

In making efficiency tests of gas engines and in determining the solid matter, moisture, and calorific value of gases, methods have been used and apparatus designed by Mr. C. E. Sargent which give uniform and rational results heretofore obtained through more tedious operations. This apparatus recently formed the subject of a descriptive paper read before the American Society of Mechanical Engineers.

In order to determine the heating value of a gas it is necessary to utilise all the heat of combustion in doing tangible work which can be measured without error or loss. The heat of combustion of a measured quantity of gas is used to raise the temperature of water; and the quantity of water,

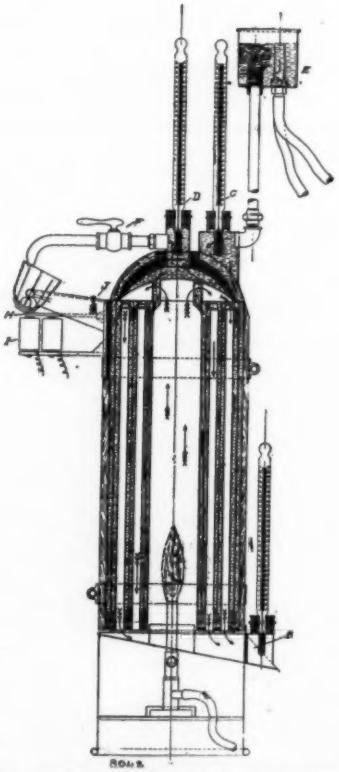


FIG. 1.—DETAIL OF "SARGENT" GAS CALORIMETER.

the rise in temperature, and the volume of gas are the three factors necessary to get its calorific value.

In the apparatus used by the writer, the inlet water, the temperature of which should be practically that of the surrounding air, envelops the whole calorimeter, thereby carrying in the heat which it might absorb from the water whose temperature is rising.

Fig. 1 shows a section of a calorimeter in which the inlet water, having a constant head at the cistern, *E*, the temperature of which is taken at *C*, envelops the whole instrument and passes through in the direction of the arrows ⋙⟶, and the rise in temperature is taken by the thermometer at *D* before any heat is lost by radiation to the air. The combustion of gas takes place in the central flue, and the products of combustion pass to the top and down the annular chambers in the direction of the arrows ⋙⟵, reaching the temperature of the water before passing out at *B*, where a damper regulates the velocity and the thermometer gives the temperature of the exhaust products.

The calorimeter should be operated in a closed room free from air currents, which disturb the equilibrium and vitiate results.

By weighing the discharged water and using Fahrenheit thermometers, no transformation from cu. cm. to grams, from Centigrade to Fahrenheit, or from calories to B.T.U. are necessary. Readings are direct in B.T.U. and errors of transformation and the mysteries of metric measurements are entirely eliminated.

One of the greatest errors in determining the calorific value of a gas arises when the operator attempts to switch the outlet water from one receptacle to another after a certain quantity of gas has been burned. To eliminate this personal error, the automatic dumping bucket, shown in Fig. 1, was designed. This bucket is held in position by the keeper, *H*, and spring, *J*. The weight of the water on the full side tends to oscillate the bucket so that the water will flow into the empty side and through another outlet to the empty receptacle. When the test meter needle passes the zero point an electrical circuit is completed, which, passing through the solenoid, draws down the keeper, *H*, and allows the outlet water to automatically change from the full to an empty pail.

By switching the water for every tenth of a cubic foot of gas burned, observations are taken about every four minutes, and the calorific value can be determined for the preceding test before the meter needle completes its next rotation. In this way a test may continue without intermission as long as the engine is in operation, or the producer is furnishing gas.

If the thermal efficiency of an engine is desired, the calorific value of the meter gas only is necessary, but for the sake of comparison, the B.T.U. are usually given in cubic feet of standard gas.

In testing producer gas below atmospheric pressure it is necessary to raise the pressure with a water ejector, but as this may add more or less water to the gas, the pressure is preferably raised with an electric or hydraulic driven centrifugal fan, as no moisture is added to the gas by this method.

The Premium-Bonus System.

In the course of a paper on works management, recently read before the Institution of Automobile Engineers, the author, Mr. Percy Martin, made some interesting observations on the premium-bonus system. Arguing that the highest possible or maximum rate should be paid for skilled labour, instead of, as many managers seek to do, paying the minimum rate, the author stated in support of this principle that the payment of maximum rates gave a larger choice of labour, and, maximum rates being paid, the best men could be chosen and retained.

Being certain of retaining your labour and having confidence in the thoroughness and reliability of your operators, it was then a matter of obtaining the maximum results from your men, not by driving them, but by a system of induction which enabled the operator to participate in the results achieved by any extra efforts he might have to put forth.

To condense the foregoing remarks into one principle, this meant that one should pay the highest possible rate that a man can earn—but see that he earns it.

The mistake was too often made of judging of the wages bill according to the individual earnings per man. The only standard from which it was possible to judge your wages spent, was the relation it had to the output of the factory, worked out in units. It was not so much what each man earns individually, as what is produced in your works by the payment of so much in wages; and methods must be sought, not to reduce the rate of pay of your men, but actually to increase it, taking care such increase was more than recompensed by

the extra output achieved. This led on to the consideration of the bonus system of paying wages as a means of increasing earnings of men, and ensuring at the same time more than a corresponding increase in the output. The principles of the bonus system, as set out by Mr. Martin, are chiefly as follows:—Divide up work in the factory into jobs, considering these jobs as units of work. Each of these jobs is provided with a time allowance by the rate-setting department. These allowances should not be fixed by the old method of observation, but from charts and curve tables, of data established by actual previous results in different metals, operations, &c., or from other accepted sources of information.

It has long been an established fact that time taken on work which can be performed by hand is capable of being estimated with tolerable accuracy, whilst work performed on machinery can be forecasted with something approaching exactitude, so that, given the operations and data necessary for the performance of work, times that an average man should occupy can be readily fixed.

These times being set on all jobs, the actual time taken on the job is deducted, and the balance, which is time saved, is divided up between the workman concerned and the company in proportions determined by the latter. In the author's opinion an equal division is best.

It was pointed out that the bonus is not intended for the exercise of mere extra physical effort, as it must not be supposed for a moment that this is our sole object. Extra physical effort cannot be maintained for long, but the utility of the bonus system undoubtedly prevails through the incentive to increase the output by continued and uninterrupted work, and in the encouragement of these small economies of time which can only emanate from the intelligence and ingenuity of the workman himself.

One of the rules which a manager should lay down strictly to his staff is that time allowance, once fixed, must not be reduced. With the bonus system, and its stated object of profit-sharing, one should never lose the confidence of the men by breaches of contract such as this, and Mr. Martin unhesitatingly condemns the action of firms who do this as unjust, besides being an extremely short-sighted policy, and detrimental to their own interests.

Another feature of the bonus system in its application to the labour is the increase of output due to the effects of the system.

This increase in output per unit of time is very far-reaching in its effects. We know that whether a factory is fully occupied or only partially occupied certain establishment charges are being incurred, and we know that this cost is to be distributed in certain proportions over the articles or units made. If the output is increased, the amount of establishments to be added per article or unit is less, thus reducing, still further, the actual cost. Thus, the factory equipment is made more valuable on account of this effect of the bonus system in producing a greater output than before. Again, the desire on the part of men to earn bonus naturally reverses the usual tendency of the offices, pressing the works for delivery. The pressure, on the contrary, is exerted right from the other end—that is, it is the man, or the men individually, who are always pushing and scheming to ensure a continuity of work with the object of increasing their earnings, and the stores, therefore, are forced automatically to push for, and get in, the material to avoid any friction in which they would probably come off second best. In other words, instead of the staff driving the works for output, the works drive the staff to supply them with the necessary material, and jobs are finished off by virtue of fresh ones pushing them out.

Live Steam Heating and Thermal Storage.*

Live steam heating is not so efficient as thermal storage, nor does it give so high a duty, as the latter takes steam from the boilers at light load for storage purposes, returning it to the boilers just when most required, thus maintaining a more uniform load on the boiler—a point of the utmost importance. With live steam heating, however, steam is taken from the boiler to heat the feed just at the time it is most required. The increased duty and efficiency with live steam heating are due to the fact that water is put into the boiler at steam temperature, and, therefore, the boiler is used solely for evaporating the water and not for heating it up. It being raised from a temperature of 250° F. to the temperature of steam at 170 lbs. absolute, each pound of water absorbs about 120 B.T.U., but in evaporating one pound of water at that pressure 854 B.T.U. are absorbed. So that in evaporating the water, heat is being absorbed at a much higher rate, and the transference of heat

* Mr. H. B Maxwell, before the Glasgow Section of the Institution of Electrical Engineers.

through the plates will be very much greater.

The causes of efficiency with thermal storage are the greater heat absorption, as stated above, as well as the more uniform load on the boiler. The increased duty and efficiency that have been obtained with thermal storage are, however, so enormous as to be hardly accounted for by these two items alone. The increased efficiency has been known to be as great as 25 per cent. after thermal storage has been installed, and duties of over 13 lbs. per square foot of heating surface per hour have been obtained with chimney draught alone It is an undoubted fact that it is less severe on a boiler to work at high duties with feed at boiler temperature than to work at lower duties with colder feed. This is proved by the researches of several prominent physicists. Another advantage of thermal storage is that any impurities in the water are deposited in the storage tanks instead of in the boilers. As no heat is transferred through the plates, scale does no harm whatever.

It should be remembered that with thermal storage the economiser may be smaller, and the feed pumps of smaller capacity, as they have only to deal with the feed at the lower loads, the feed being taken from the storage vessels at high loads. When working with feed from the storage tanks it is necessary to pass a small amount of water through the economiser to prevent overheating, and this should be regulated so as to give as high a final feed temperature as possible. In actual working the speed of the pump would be reduced as the load increased, and it is unlikely that the speed would be reduced to the minimum mentioned above except in the case of abnormally big loads, as it would be desirable always to have a little in reserve to meet such emergencies.

The Production and Distribution of Music by Electricity.

Daily musical performances are at the present time being given in a concert room

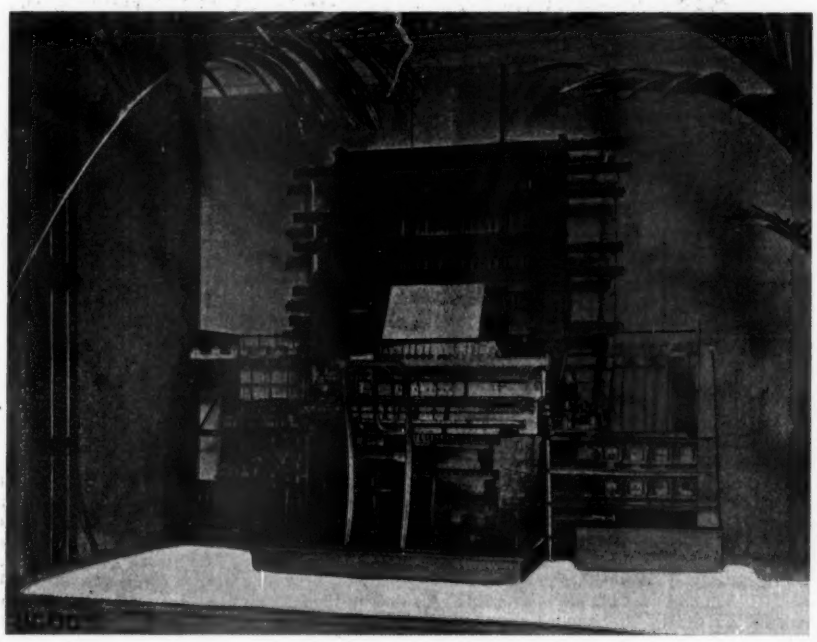


FIG. I.—KEYBOARD OF THE TELHARMONIC SYSTEM.

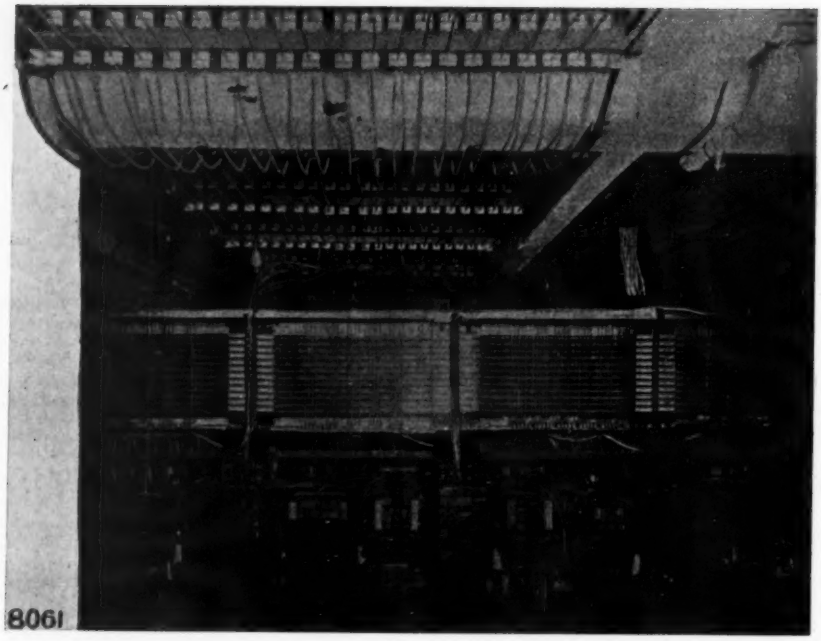


FIG. 2.—PART OF THE SWITCHBOARD AND TONE MIXERS OF THE TELHARMONIC SYSTEM.

and several hotels in New York by means of an apparatus which produces a high quality of musical sound, and effects the distribution of music from a central station without the use of any musical instrument.

The Telharmonium, which is the name of the new music-producing apparatus, is, according to the *Engineering News*, to whom we are indebted for the following particulars, purely an electrical machine by whose operation a musician may produce any music known to the human ear. The sounds are produced by telephone receivers provided with horns of the megaphone type, some of which are located in the concert room. The music issuing from the horns is sufficiently powerful to fill an ordinary room, being about the same in loudness as that from a violin or piano, and the horn from which it issues may, if desired, be entirely concealed from view.

With the exception of the keyboard, Fig. 1, which is located in the concert hall previously referred to, the apparatus of the plant is in the basement. Here is a series of 144 electric alternators, each giving a current of a certain frequency. When these currents are sent into a telephone receiver they cause the diaphragm to give out a musical note of a pitch corresponding to the number of alternations. When the musician presses down a key on the keyboard, a magnetic circuit is closed on the switchboard, Fig. 2, which causes a rod to be lifted and the currents from one or more alternators to be sent over the wire. Before passing out to the distributing lines, however, these currents are tempered and blended by the tone mixers shown in the lower part of Fig. 2.

The alternators are driven by a 185 h.-p. constant speed direct-current motor. They are of the inductor type, the revolving portion of each consisting of an iron rotor with pole pieces corresponding in number to the frequency desired for each particular machine. The range of frequencies thus obtained from the 144 alternators is from 40 to 4,000 cycles per second. By depressing any certain key on the keyboard there results a current in the telephone

receivers which causes their diaphragms to vibrate so as to correspond in frequency to the ground tone of the desired musical note and the various partials or overtones, the loudness of the latter being under the control of the musician.

There are two keyboards equipped with 144 keys each, enabling two musicians to play simultaneously, and together to have control over twenty keys at any one time. These keys, however, do not act directly upon the circuits from the alternators, but actuate plunger magnets which, in turn, control these circuits. Each magnet when actuated draws up a strip of wood which carries a set of fingers serving to actuate the switches corresponding to the ground tone and overtones of the desired note.

The bus bars on the switchboard are so arranged that the currents producing the ground tones are superposed in one circuit, and the currents for each of the overtones are superposed in separate circuits. The currents in these circuits pass through the primaries of closed iron magnetic circuit transformers, and in the secondaries of these transformers are impedance rheostats controlled by the musician for varying the strengths of the currents. The secondary currents are next led through the primary winding of an open ironwork magnetic circuit transformer, the secondary current from which passed through the primary of an air-core transformer, and the secondary current from this actuates the various receivers.

The reason for using three transformers instead of one are the elimination of annoying overtones which otherwise assert themselves and the greater opportunity afforded of controlling the values of the different factors entering into the final result.

It is claimed that with a properly equipped central station, the Telharmonic music could be distributed to all the residences within a radius of 150 miles of New York City. A half dozen operators at the keyboards could duplicate the effect of an orchestra of 150 pieces, and an audience of a million people could listen at once to the resulting music.

Greenwich Observatory and the L.C.C. Engines.

During the past month the full report of the committee appointed to inquire into the vibration troubles set up by the engines at the L.C.C. generating station has been presented. Among the proposals submitted, which include the installation of turbine plant for the second portion of the station, was that when the turbine plant was available the reciprocating engines should not be run after 8.30 p.m. It was further pointed out that the latter admitted of being completely balanced, the method being explained in detail by Professor Dalby in an appendix to the report which is here reproduced.

From the drawings and the schedule of the weights sent to me I find the state of the plant regarding balance to be as follows :—

Each engine considered separately :

(1) The balance weight on the engine formed by the prolongation of the crank arm in the contrary direction to the crank is only sufficient to balance the revolving masses of the engine. By "revolving masses" I mean: The crank pin, the crank arm, a proportion of the high-pressure connecting rod, a proportion of the low-pressure connecting rod.

(2) The reciprocating masses both vertically and horizontally are unbalanced.

The maximum value of the vertical unbalanced force at 94 revolutions per minute is 23 tons approximately, so that during each revolution a vertical force of 23 tons acts along the vertical centre line of the high-pressure cylinder to alternately lift and depress the foundation block at this point.

The maximum value of the horizontal unbalanced force at 94 revolutions per minute is 40 tons approximately. This force acts along the centre line of the low-pressure cylinder, and tends to oscillate the foundation block horizontally.

The unbalanced forces acting on one foundation block, due to the pair of engines bolted to it, the two engines driving one generator.

The cranks of the engines are set on the common shaft at an angle of 135 degrees. This angle is chosen, I presume, in order to obtain as uniform a turning effort as possible, because with this arrangement the maximum turning efforts from the four cylinders coupled to the shaft follow one another at intervals of 45 degrees, assuming that the indicating cards from the four cylinders are similar.

The effect on the block in the horizontal plane is that due to—(1) An unbalanced horizontal force of three tons at 94 revolutions per minute; (2) An unbalanced horizontal couple of 1,200 foot tons approximately.

Fig. 1 shows the couple in its relation to the block at the instant when it is acting with its maximum value to twist the block.

The full lines indicate the couple acting to turn the block in the clockwise direction, the dotted lines the direction of the forces about three-eighths of a second afterwards, and tending to turn the block in the opposite direction.

Fig. 2 shows a similar sketch for the couple produced by the unbalanced reciprocating parts of the high-pressure cylinder.

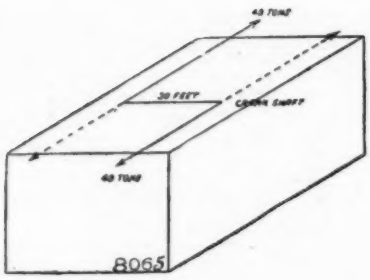


FIG. 1.

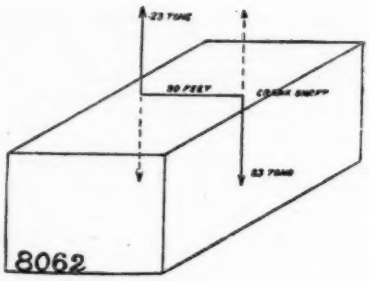


FIG. 2.

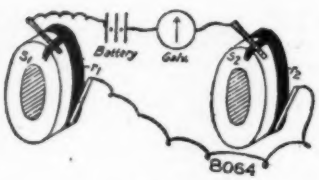


FIG. 3.

The effect on the block in the vertical plane is that due to—(1) An unbalanced vertical force of two tons approximately; (2) An unbalanced vertical couple of 690 foot tons.

That the block moves in consequence of both these couples is, I think, shown by the record of observations made with a saucer full of mercury on August 15th.

The unbalanced forces acting on the concrete mattress on which the foundation blocks are set when two generators are running, and are electrically coupled in parallel.

When two generators are coupled in parallel the engines corresponding to them are electrically geared together with their crank shafts at the particular angle they happened to occupy relative to one another at the instant they were "paralleled."

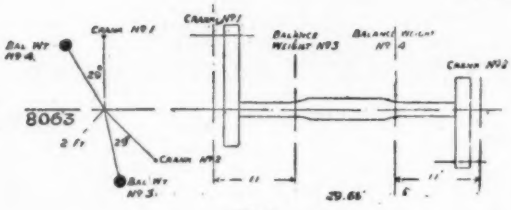


FIG. 4.

If the cranks were parallel, and in the same direction at the instant of "paralleling," the unbalanced coupled from each set are additive, and there would be a couple acting on the mattress from the two blocks of about 2,400 foot tons at 94 revolutions per minute horizontally, and 1,380 foot tons vertically. If, on the other hand, the engines were paralleled, when the cranks were parallel, but opposite, the couples would tend to annul one another.

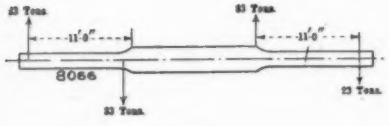


FIG. 5.

It is possible to put the two generators in parallel at the instant the cranks have the proper angular relation, by means of an instrument of the following kind, shown in Fig. 3. A commutator is placed on each shaft constructed, so that one side of it r^1 is metal, and the other side is an insulator at one point of which is a metal bar joined to the ring r^1. Brushes are arranged as shown, and a circuit is formed of a battery and galvanometer. The two metallic parts r^1 r^2 of the commutators are connected as shown. From the figure it will be seen that the current can only flow when the shafts have the angular position relatively to one another determined by the metallic pieces s^1 and s^2. The indications of the galvanometer taken in conjunction with those of the "Synchroscope" fix the instant at which the machines are to be

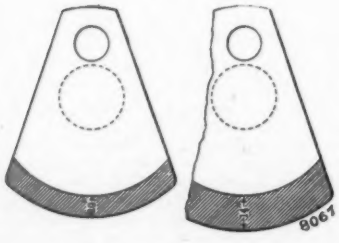


FIG. 6.

paralleled. The process takes a considerable time, but it is a certain way of electrically coupling the engines, so that the crank shafts are in a good working position to avoid vibration.

Methods of Balancing the Engines.—The only way to completely balance the engines is to add a mass of 2·67 tons to the h.-p. reciprocating parts in order to make the vertical unbalanced mass equal to the horizontal unbalanced mass, and then add a balance weight equivalent to 6·56 tons at 2 ft. radius directly opposite the crank pin. This is impracticable, because there is no room in the crank pit to allow the addition of the necessary mass to the crank arm.

To balance the vertical forces completely, leaving the horizontal reciprocating masses partially unbalanced, it would be necessary to add a balance weight equivalent to 3·9 tons at 2 ft. radius to the crank arm directly opposite the crank pin. This is also impracticable. The nearest approach which could be made to this would be to drill holes in the existing balance weights and fill them with lead; but very little balancing could be effected by this method, because the effective mass of lead added would only be represented by the difference between the weight of lead added and the steel removed.

There are two places on the crank shaft where it is possible to place balance weights, and I have accordingly worked out their magnitudes and positions in order that they may completely balance the vertical unbalanced reciprocating forces. At the same time these weights will balance about two-thirds of the unbalanced horizontal forces. The positions of the weights are indicated in Fig. 4. The magnitude of each weight is equivalent to 13·8 tons at 2 ft. radius. The masses and angles are approximate only, being calculated from data supplied to me. It would be necessary to go into the matter a little more closely if the work were carried out. The addition of these masses to the shaft would impose serious additional loads. At 94 revolutions per minute these balance weights would each be equivalent to a static load on the shaft of 83 tons. The inertia loading of the shaft would be approximately as shown in Fig. 5. It will be seen from the figure that although the forces acting form approximately two equal and opposite couples, and thus relieve the bearings of the inertia strain, yet the shaft is considerably more strained than it is at present, and it is a question whether the engine builders would consider it safe to impose the additional loading. Of course, these straining actions are additional to the straining actions due to the steam pressures.

Finally, there is no doubt but that the first method of balancing considered above would be by far the best, and I would suggest that the builders be asked for an estimate for increasing the size of the crank pit, and then adding the balance weight where it ought to have been put at first, namely, in the prolongation of the crank arm. To completely balance by this method, the crank arm would require to have the balance weight side about 14 ins. longer. And to balance the vertical forces alone the additional length would be about 10 ins. The two sketches in Fig. 6 indicate these additions by cross-hatching.

The New Naval Docks at Devonport.

With the completion and opening of the new docks an extension of nearly 120 acres has been added to the naval establishments at Devonport. Constructed at a cost of near four millions, the works comprise a closed basin, having an area of 35½ acres, and a tidal basin of 10 acres area. A space about 900 ft. long separates these, and in this intervening area three large graving docks have been constructed. The following details are extracted from a lengthy and well illustrated description appearing in *Engineering*.

The total length of the closed basin is 1,550 ft., and the width about 1,000 ft. The uniform depth of water at low water of ordinary spring tides is 32 ft. 6 ins., and at high water, 48 ft. The walls of the basin are built of concrete, faced with limestone. They have a thickness of 30 ft. at base, and a height from the floor of the basin to the coping of 55 ft., but they extend into the subsoil for a considerable distance, having been built in trenches varying in depth to a maximum of 90 ft. from the original surface.

A pier, 500 ft. in length, projects into the basin from its northern end. This increases the length of the quayage within the basin to 5,000 ft.

The main entrance to this dock from the Hamoaze is through an entrance lock, and is made suitable for the dry-docking of ships. It has a length of 730 ft., with the ordinary sliding caissons; but here, as in the graving-docks, arrangements have been made for using floating caissons against outer stops, whereby the length available for ships within the dock is increased to 787 ft. The width of the entrance at coping-level is 95 ft., and the walls have a batter of 1 in 12, rounded off with a radius of 5 ft. at the sill. The depth over the sill is 32 ft. at low water of ordinary spring tides, or 47 ft. 6 ins. at high water. Concrete was used for the greater part of the construction. The facings are of granite, except in the upper altars and the top vertical walls, where granolithic concrete blocks are used with granite coping. The total height from the sill to the coping is 55 ft. In addition to

this lock there is a direct entrance, with sliding caisson, from the harbour to the closed basin.

The tidal basin is 600 ft. long and 740 ft. wide, the length of the wharfage being 2,000 ft. The entrance to this tidal basin is 120 ft. wide, the river wall on each side of the entrance being 60 ft. wide at coping-level. The north round head of the tidal-basin entrance and the whole length of the outer or river wall were constructed within a cofferdam by the sinking of concrete columns in trenches.

Two of the three graving-docks have an entrance at each end—at the north from the closed basin, and at the south from the tidal basin. Stops have been constructed at mid-distance in the length for floating caissons, so that both docks may be divided into two independent parts, to accommodate two vessels. The larger part of each divided dock will accommodate, in the one case, a ship 462 ft. long, and, in the other, 459 ft. long. The smaller part of each divided dock takes a ship 250 ft. in length. Undivided, the central dock has a length of 745 ft., and the western dock of 741 ft. By the adoption of a floating caisson these lengths may be increased by 43 ft. The western dock has a depth of water over the sill of 32 ft. at low water of spring tides, or of 47 ft. 6 ins. at high water. Thus at almost any stage of the tide any of our warships, even laden with war stores, may pass in from the tidal or the closed basin to this dock. Even if water-logged, as the result of damage in war, they could enter this dock at nearly all stages, excepting at low water. The central dock has a depth over the sill of only 20 ft. 6 ins. at low water of spring tides, or of 36 ft. at high water.

The third graving-dock, with one entrance from the closed basin, is 660 ft. in length. The entrance in this case is similar in section to the other docks, and the depth of water over the sill, as in dock No. 9, is 36 ft. at high water of spring tides. The walls are 43 ft. 6 ins. high to coping-level. In this case, also, the available length can be increased by 43 ft. by the use of a floating caisson in the outer stops.

Mechanical Draught for Steam Boilers.*

In considering economy it is necessary to compare the original cost of a high chimney with that of a fan and low iron stack, and also the cost of working the chimney with the cost of working the fan. There is also to be considered the cost of the apparatus used to cool the gases in order that the economy due to the abstraction of their heat may be secured.

It has been shown that chimney draught absorbs about one-fourth of the total power of the boiler. In a boiler plant of 2,000 h.-p. there may be 1,500 h.-p. developed at the engine, and the remaining 500 h.-p. absorbed by the chimney. Thus, it costs 500 h.-p. to produce a draught for 1,500 h.-p. nett. If a fan and sufficient economiser pipes are used, the amount of excess of air may be reduced from 12 to 6 lbs. There will then be 18 lbs. of air entering the chimney per pound of fuel instead of the usual 24 lbs., that is, there will be an economy of 125 h.-p. Of the 375 h.-p. still going to waste at 650° F. another 125 h.-p. may still be saved by the use of economiser pipes or other heat absorbing apparatus. Altogether there will be an economy of 250 h.-p., representing a final flue temperature of approximately 300° F., and this admits of further economy by extending the heat extraction appliances.

The power absorbed by a well designed and correctly applied fan is about 1 per cent. of the total power of the engine supplied by the boilers. Thus, in the case under consideration, the fan will absorb about 15 h.-p., therefore, the nett saving will be 235 h.-p., that is, about 16 per cent. Even if no heat absorbing apparatus is used the first 125 h.-p. saved by the fan may be relied upon. This follows from the fact that the fuel has not to be spread in thin layers, and that less excess of air is required. It has been found that with a good draught and thick fires the air supply may be reduced to less than 15 lbs. per pound of fuel.

From steam boilers with a low rate of combustion per square foot of grate surface, it is possible to obtain very economical results, or to largely increase the rate of combustion without loss, and in most cases with considerable gain.

Generally, it may be taken that there is greatest economy in working when that fuel thickness is used which is the greatest possible with the available draught without excessive stirring of the fire.

When this maximum thickness has been found, the grate area is then cut down to that necessary to burn fuel sufficient for the production of the steam required, leaving of course a margin of draught available to be used when there is a sudden demand for extra steam.

* Abstract of a paper read by J. Crawford, M.I.Mech.E., before the Manchester Association of Engineers.

These results can only be obtained by the aid of mechanical draught. The steam jet may be left out of the question as a draught producer, for although it may be cheaply applied, it is costly to work, using in many instances as much as 12 per cent. of the total steam generated. Steam jet furnaces, however, show an economy because cheap fuel can be used with them, and the jet may thus save more than it costs.

For boiler draught the design of fan should be simple in construction, and arranged to run at a low speed of revolution. As the fan revolves the vanes carry air round with them, and as this air tends to move in a straight line it will leave the fan tangentially at any opening available.

More air to take its place enters at the fan inlet, and also in its turn escapes tangentially with a velocity approximately equal to the peripheral speed. It follows from this that the tip of a fan blade must move at such a speed as will produce the velocity in the movement of the air that would be given by a draught of the intensity required.

Say that the draught required is to have an intensity equal to 1 in. water gauge. The laws governing the flow of gases are the same as those for liquids. The velocity of flow depends upon the height of the column equal to the pressure. Therefore, at ordinary atmospheric pressure and temperature, the pressure on a square foot is 2,115 lbs. One cubic foot of air weighs 0·0778 lbs. at 52° F. Hence, if a column of air at atmospheric pressure is of equal density throughout it must have a height of $2{,}115 \div 0{\cdot}0778 = 27{,}160$ ft. The formula for the flow of a fluid is $v = \sqrt{2\,g\,h}$; where v equals the velocity of a body in feet per second, h is the height in feet from which the body has fallen, g is 32·2 and represents the effect or acceleration due to gravity in England.

Therefore a column of air would flow into a vacuum at a velocity per second equal to $\sqrt{64 \times 27{,}160}$ or about 1,320 ft. per second. A pressure of 1 in water is equal to 0.578 of an ounce per square inch.

An atmosphere of pressure is 235 ounces per square inch, therefore it follows that 0·578 ounce is $\frac{1}{407}$ of an atmosphere, or say 66 ft. The velocity due to a head of 66 ft. is thus $\sqrt{64 \times 66}$, or about 65 ft. per second. When a chimney draught is used a flow of 30 ft. per second is considered as a minimum for smoke prevention, double this would therefore be a very good draught.

As a rule the formula used for draught velocity is 65·5 H where H is the water gauge produced in inches.

The power to drive a fan increases as the cube of the velocity. Therefore, for economical working, the speed of a fan must not exceed that necessary to produce the required draught. In other words, it is very wasteful of power to use a small fan driven at a high speed of revolution in order to deal with a volume of air beyond its capacity. It is therefore desirable, from an economical point of view, to employ a fan of sufficient size to work with the volume of air required at the lowest speed consistent with the duty required from the boilers. The fan tip must revolve only at such a velocity as will produce the necessary draught.

Universal Soldering Fluid. — A soldering fluid which has proved very useful in certain railway shops is made, says the *Street Railway Journal*, by killing two quarts of hydrochloric acid with all the zinc it will take up. Then to the acid a quart of water is added, or it may have to be added before the zinc will fully dissolve. A quart of glycerine which has previously been mixed with a quart of alcohol is then added to the solution. This fluid is used for all kinds of soldering and has been found especially desirable with greasy or dirty connections, as well as for soldering to iron. It is claimed that the glycerine prevents all rust, which plays havoc with many soldering fluids which contain hydrochloric acid.

An Electrolytic Method of Sharpening Tools. — The *Elektrotechnischer Anzeiger* gives the following method of sharpening files and other similar tools. The file is connected with the positive pole of a battery consisting of 12 Bunsen cells, and is then placed in a bath made up of 40 parts of sulphuric acid and 1,000 parts of water. The negative electrode is of copper wire wound in spiral form round the file, but not touching it. The action takes about 10 minutes. It is said that files treated in this way appear to be quite new, and are satisfactory in use.

NOTES AND COMMENTS.

The transmission of power for long distances has hitherto not been a question of much practical importance as far as this country is concerned. The undoubted tendency to develop supply areas of ever increasing extent is, however, forcing the problem on the attention of British engineers and brought forth at a recent meeting of the Institution of Electrical Engineers one of the most interesting papers of the session. The author, Mr. Highfield, put the case for the direct current series system, one which has been developed on the Continent, with highly successful results, by M. Thury, culminating in the Moutiers-Lyons transmission of 4,300 K. W. at 57,600 volts. The practical difficulties experienced with alternating currents such as resonance effects, &c. are well known, and it is the absence of such complications in direct current working that has been one of the elements responsible for the successful development of the direct series transmission.

Mr. Highfield summarises the advantages of the latter over the parallel system as follows:—(1) The ability to extend the possible commercial transmission distance far beyond that possible with alternating currents, and particularly in those cases where underground transmission is essential. (2) Simplification of switch and regulating gear: (3) Easy working of several stations in series on the same loads, so that more efficient run always, and the less efficient run only, on the peak load: (4) The uniform section of the mains permits an increasing load supplied at first from one point to be readily provided for by the addition at any other suitable points on the main of other stations without addition to the cable system. (5) Efficient speed regulation of sub-generators where certain special loads, such as chemical loads, are to be served from a distance. (6) Greater all round efficiency to be obtained when the generators by turbines worked from a water-fall having a great percentage variation of head.

According to figures given by Professor Kapp in connection with a transmission plant to Zurich other advantages become apparent. In this case the prime cost worked out in favour of the direct current system over the three-phase to the extent of £2 per K. W., and in the case of the line, the three-phase cables compared enormously unfavourably with single line cables, the former costing £156,000 and the latter only £78,000.

Although there is very little to be said against the alternating current system with its ease of transformation without moving parts and its elasticity where additions are concerned, it is nevertheless not advisable to allow what may best be described as a natural dislike for innovations to prejudice us against a system which has been shown to be capable of simple, easy and efficient working.

The ultimate transformation of the lonely downs of Kent into centres of industry such as exist at Liége and Valenciennes was a prediction made by Professor W. Boyd-Dawkins, the well-known coal expert, at a recent meeting of the Society of Arts in the course of a lecture on the discovery of coal in Kent. This sanguine forecast was based upon the evidence of borings made during the past twenty years, which prove the undoubted existence of coal measures at depths ranging from 1,000 feet downwards. As the evidence stands at present the seams proved in the Kent field are as follows:—Thirteen at Dover in Pennant Grit aggregating 22ft. 6in., twelve thin seams at Ropersole, four at Waldershore in the Lower Shale series, aggregating 10ft. 3in., and three at Fredville totalling

7 ft., the latter being the most recent borings carried out during the past two years. According to the Professor, the coalfield, of which the area comprised by the above-mentioned borings forms a part, is probably a large narrow trough as in North France and in Belgium, one of a series extending north-westwards from Dover under the newer rocks linking the above coalfields with those of Somerset, and is probably not less than 8,000 ft. thick. We are among those who prefer to adopt a cautious attitude as to there being payable coal in sufficient quantity to bring about a transformation, such as the Professor foresees on the Kentish country-side; but that he has brought certainty much nearer than when the idea of the existence of these very coalfields was first advanced by Godwin-Austen in 1856, and the original discovery at Dover in 1886, is shown by the fact that there are in existence to-day one company to whom mining rights have been granted, and several smaller enterprises actively engaged in sinking shafts and bore-holes under the direction of Professor Dawkins.

The Commercial vehicle in general, and the Motor Omnibus in particular, have been in the foreground of public interest during the month just passed. The latter has engaged the attention of meetings of the Society of Arts and of the Institution of Mechanical Engineers, and we have had the first Exhibiton of Automobiles from which the pleasure car was excluded. This inhibition of the private passenger vehicle is not without its significance, as it points to the fact that an important stage has been reached in the development of the commercial motor, namely, that it has arrived at that pitch of perfection and popularity as to bid fair to supersede the heavy horse-drawn delivery van or lorry, and has given rise to an industry which has already secured a stability which the manufacture of pleasure cars can hardly be expected to maintain. The heavy steam vehicle did not figure at Olympia to the extent as was perhaps to be expected, although we should be the last to deduce from this that steam is not capable of holding its own against its petrol rival. If the development of the steam wagon has not been as rapid as was at one time expected, it is not due to any inherent disadvantage attaching to steam plant, or to any imperfection in workmanship, but rather to the careless handling on the part of the drivers, owing to which breakdowns have occurred.

In connection with the motor omnibus, which formed the most attractive feature of the exhibition, the challenge offered by the petrol-electric system of transmission—of which there were several examples—to the direct motor drive, is worthy of note. In spite of the introduction of highly ingenious and accurate machines for the cutting of gears and other improvements in manufacture, it appears impossible to entirely eliminate the noise arising from the gear box. It is to overcome this and other disadvantages attaching to the employment of change-speed gear that the new petrol-electric system is being introduced, and whatever criticism may be urged against it by reason of added complication, weight, first cost, and the double conversion of energy involved, there are compensating advantages in the shape of increased efficiency, ease of control and noiselessness to justify its consideration.

ELECTRICAL ENGINEERING NOTES.

By ANDREW STEWART, A.M.I.E.E.

Railway Electrification.

This subject is again one of the principal features of the month's engineering literature. Mr. Philip Dawson deals with the results on the Metropolitan, District, Lancashire and Yorkshire, and North Eastern Railways, and the probable results on the London, Brighton, and South Coast Railway, in *The Times Engineering Supplement*, and the paper by Messrs. Stillwell and Putnam, read to the American Institute of Electrical Engineers, was of interest, inasmuch as it recorded some experience obtained in connection with heavy electric traction, especially with regard to the financial aspect of the problem, and the importance of standardisation in connection with the system of supply and periodicity.

Mr. Dawson dealt with the disappointing results on the Metropolitan and District Railway, pointing out that the rapid acceleration demanded on electrified suburban lines, in order to obtain high average speed between stations, raised the power costs to a figure greater than the fuel and similar power costs in the days of the old steam locomotives. If those working such railways were content with the same acceleration as is now obtained with steam, the power costs could be reduced below that ruling for steam. The main object of electrification is not, however, reduction in operating costs, but increase in revenue, which can only be obtained by running a more frequent service and maintaining higher speed in order to attract traffic from other lines.

The District, and in a lesser degree, the Metropolitan, are paralleled by omnibus routes, which are being rapidly equipped with motor omnibuses; these attract much short distance traffic, and a fair amount of long distance traffic. Moreover, the two lines mentioned, even in the old steam days, obtained most of the traffic then moving, as the only alternative was the horse omnibus; so that it is difficult to see where any large increase in the traffic was to come from. In this respect Mr. Dawson thinks that the Americans, basing their figures on results obtained in the United States, and without the local knowledge necessary to enable them to grasp the intricacies of the problem, went astray in predicting a large increase in the revenue from fresh traffic; moreover, they altogether failed to foresee the early introduction of the motor omnibus, and its modifying influence on their conclusions, as the lines are now paralleled, east and west, by alternative services, reaching as much as twelve miles per hour, with the advantages of surface transit.

The London, Brighton, and South Coast electrification scheme has many advantages; it is on the surface, is in no case absolutely paralleled by competitive lines, though, in parts it is touched by a system of electric tramways, which, however, have done their worst, and will no doubt have to yield up some of their traffic to the electrified railway, just as in the case of the North Eastern

Railway, the electrification scheme practically rejuvenated a line which was hard hit by tramway competition.

Messrs. Stillwell and Putnam gave a good deal of data acquired on American lines, but the experiences of the District and Metropolitan Railways will no doubt prevent British engineers from blindly following American precedent, though after all, these lessons are, or ought to be, unnecessary, as it has for long been recognised that American engineering is distinctively American, and results obtained there are not necessarily possible elsewhere. This is true, not only of American railway practice, but has been found more or less accurate when applied to American machine tools, and other machinery which have not proved quite as satisfactory, either here or on the Continent, as they are generally supposed to be in the United States.

Notwithstanding this, there is a good deal of information of value to British engineers, particularly with regard to the tendency of American single-phase systems towards a uniform periodicity. As we have already pointed out, each railway company exhibits a tendency to work along different lines, and so far as this exhibits a healthy tendency towards improvements in construction and operation, it is to be commended; but we have shown that want of uniformity in selecting a periodicity is likely to prove a very serious matter when these lines become linked up. When dealing with this point the authors of the paper in question gave a good deal of information on the influence of the periodicity on the cost of the equipment. For instance, an electric locomotive which, for a 25-cycle circuit, would cost £5,000, could be built for £4,800 if constructed to operate on a 15-cycle circuit, notwithstanding the extra cost of the transformers on the locomotive. Three-fourths of the cost of an electric locomotive represents the cost of the electrical equipment.

The turbo-generators will, it is stated, cost rather less for 15-cycles when compared with 25-cycles.

Fifteen-cycles also have advantages on the track, as the lower inductive drop in an iron rail with the lower periodicity, will reduce the amount of copper necessary to supplement the track circuit. During the discussion Mr. Frank J. Sprague asserted, as he has frequently done, that direct current at 1,200–1,500 volts will be the system ultimately adopted for main line traction, and promised the institute a paper on the subject at an early date.

Mr. B. G. Lamme, of the Westinghouse Co., advocated 15-cycles, as a given motor at this frequently gave 25 to 40 per cent. greater output than at 25-cycles. He also pointed out that the single phase *series* motor for 25-cycles operated well at 15-cycles, and a 15-cycle motor fairly well at 25-cycles. He also pointed out that while important European companies like Ganz and Co., the Oerlikon Co., and the Siemens Schuckert Co. have adopted 15-cycles as their standard periodicity for single-phase working, the Allgemeine Elektricitats Gesellschaft, of Berlin, have adhered to 25-cycles. The excellent results which the latter company obtain is due, in some measure, to the use of the series-repulsion motor, and not merely to the higher frequency.

Quite the contrary opinion was held by Mr. Potter, of the General Electric Co., Schenectady, who said that the 25-cycle machine was superior to the 15-cycle machine, paticularly as regards maximum torque, a statement which he substantiated by the following figures. Assuming the maximum tractive effort of a given direct current motor as 100, a 25-cycle single-phase motor gave 80–90, and a 15-cycle motor 70–80 per cent. Notwithstanding this, Mr. Potter asserted that the 25-cycle motor had a relatively small output for its size; it weighs 25 per cent. more than a direct current machine of corresponding output, and a 15-cycle machine with equally good commutating properties, would only weigh 10 to 15 per cent. more. In short, it appeared from Mr. Potter's remarks that the nearer one got to direct current the greater the output and maximum torque obtainable.

There is, however, an advantage not,

we believe, hitherto noted, viz., that where the direct-current motor slips, the wheels rotate rapidly, and the torque falls off to something like 20 or 30 per cent. of the maximum, with an alternating current motor of 15- or 25-cycles; although the wheels may slip at a lower point, the torque only falls off by 10 or 15 per cent., due to the fact that the slip is a series of progressions or jerks which allows the wheel to grip the rail. After the wheel has once slipped it may therefore have a higher maximum pull than before slipping, due to the slip having cleaned the rail, and the period of slip is shorter, owing to the alternating current motor not running off as a direct-current motor would do; hence the average draw-bar pull with an alternating current motor is probably 70 per cent. greater than with direct-current.

Mr. Potter urged the study of collateral considerations when the problem is attacked, for, as he said, the 15-cycle circuit is quite unsuited for lighting the cars, and would add to the cost of the generating and transforming plant; the authors, it would be noted, claimed a reduction in the cost of the generating plant, and an increase in the cost of the transformers for the lower periodicity. It is probable, however, that 15-cycle turbo-alternators would be more expensive than 25-cycle machines.

In view of the many difficulties with alternating currents, Mr. Potter urged the claims of the direct-current motor at a high voltage and with commutating poles; this, he said, got rid of all the commutating difficulties, and placed the direct-current machine in a very favourable position.

Subsequent speakers voiced the claims of the three-phase and others the direct-current locomotive, though little additional data was offered in support of the claims; all, however, agreed as to the superiority of electric traction, one speaker stating that the modern steam locomotive had an i.-h.-p. of 2,000, could not do much more than its rated output for short periods, and cost approximately four to five pence per locomotive mile for maintenance, while the electric locomotive, having about 10 per cent. greater rated power, could give 25 to 50 per cent. more for an hour, and might even give 100 per cent. more for short periods, and yet only cost $\frac{3}{4}d.$ per locomotive mile for maintenance. Power charges were not mentioned by this speaker, but the authors of the paper credited the electric locomotive with a reduction of 50 per cent. in the fuel costs.

The paper and discussion proved valuable, inasmuch as there are few opportunities of ascertaining the views of engineers with experience in this class of work, and such information as was laid before the meeting did not indicate any unanimity of opinion as to the type of apparatus to be employed, though this is not surprising, considering the diverse conditions under which the small amount of experience with heavy electric traction has been obtained.

Electric Traction on Canals.

We are yet some distance from a comprehensive electrification of our canals, indeed it is possible that we may be further from this than from main line railway electrification. The work done in electrically equipping the Canals D'Aire, et de la Deule, may, however, prove of considerable interest to those of our readers who have followed the question and are acquainted with the work already carried out abroad. We have already dealt with the use of locomotives, and proportional adhesion tractors,* the former are used on the canals just mentioned, though a tractor of the Denèfle tricycle type has been used, but abandoned in favour of iocomotives running on a track. The chief considerations which led to the tricycle being discarded was its high power consumption, and the tendency which this form of tractor displayed, when starting a heavy barge,

* THE ENGINEERING REVIEW, February, August, and October, 1906.

to topple over, sometimes, by the way, into the canal. The first of these considerations was a most important one, for owing to the uneven surface of the towing path it required almost 10 h.-p. to propel itself, while the new electric locomotives require about $2\frac{3}{4}$ h.-p. when running light. This result shows, *inter alia*, how tremendously the uneven surface of a road influences the power required for traction, and indicates in an exaggerated form the difference between the power cost of a motor omnibus and an electric tramcar, showing, if proof were necessary, the initial handicap on the former.

It has now been found possible to tow a loaded barge with little more power than was required to propel the older tractor along the towing-path light.

The new locomotives run on a light railway track, and resemble the ordinary electric locomotive, but with four wheels instead of eight, each axle having a 20 h.-p. tramcar motor geared to it. The wheel base is 5 ft. 7 ins., the overall length being 13 ft., with a width of 5 ft. 3 ins., and a height, to top of cab, of 8 ft. 2 ins. The framework is of angle and channel sections, covered with a $\frac{3}{8}$-in. sheet iron plating, the total weight is eight tons, no effort being made to keep down the weight, as some considerable weight is desirable in the interests of adhesion.

The tow-rope is attached to hooks fixed to the end of the locomotive, about 5 ft. above the rail level, no special towing mast being used, though the barges themselves have a towing mast which stands about 13 feet above the deck.

The rails on which the locomotive runs are 40 lbs. per yard. The rail nearest the canal is elevated nearly $1\frac{3}{4}$ ins. above the other rail to prevent the locomotive being tilted over during acceleration, and to improve the adhesion when the side strain comes on.

The barges are 117 ft. long by 16 ft. beam and a draught (loaded) of 5 ft. 10 ins. carrying about 290 tons. As the canal has an average width of 63 ft. and a depth of $7\frac{1}{2}$ ft., the barges occupy a larger proportion of the canal section than usual. This means a high tractive effort, and on this canal it has been found that even a speed of two miles per hour requires a tractive effort of over 3 lbs. per ton. The maximum speed for loaded barges is somewhat less than this, as higher speeds damage the canal banks. Generally speaking, 10 kilowatts ($13\frac{1}{2}$ h.-p.) is required to haul a loaded barge at 1·9 miles per hour.

Only one set of rails is laid, so locomotives cannot pass one another. Should two meet, they exchange barges and reverse, repeating the process every time they meet a locomotive and barge going in the opposite direction, thus a locomotive does not travel very long distances, nor does the driver finish his day's work far from home. The line equipment costs a little over £1,000 a mile, and each locomotive £325, so that the initial cost is extremely moderate. The charges made for towing against the stream is ·0047 shillings per ton mile, and ·0044 shillings per ton mile with the stream. The canal is $35\frac{1}{2}$ miles long, 10 miles of which is equipped in the manner indicated, and it is intended to proceed with the remainder of the work at once, as well as several extensions, designed to give communication with the Scheldt, and to the North Sea.

IRON, STEEL, AND THE FOUNDRY.

Conducted by PERCY LONGMUIR.

CURRENT FOUNDRY PRACTICE.

The Manufacture of Cast Iron Car Wheels.*—Whilst the cast iron car wheel represent a specialised American product and one not likely to become common in this country, there are still many points of interest to be found in a study of its production, this the more so in that the car-wheel industry of America is the most highly developed branch of iron founding. The increase in output, now twenty-five wheels per moulder per day, is a good index of the growth and development of systematic methods of production. A singular and yet noteworthy feature of this development lies in the small part played by the moulding machine and in the vast majority of plants, whilst labour-saving devices are largely utilised, the wheels are all practically hand moulded. Continuous processes have been introduced, and one followed in the plant of the Central Car Wheel Company divides the operation into four distinct parts, consisting of the making of the top and bottom parts of the mould, casting and shaking out the boxes. Trucks carrying the boxes travel on a circular track and are controlled by a system of rope haulage. Sand is delivered by a conveyor to the moulders, and after shaking out the boxes the sand is passed through a grating into a mixing pit, where it is tempered and returned to the conveyor. In a continuous system followed by the American Car and Foundry Co. moulding machines of the squeezer type are utilised. Trucks carrying the boxes operate on a rectangular narrow-gauge track system, the moulds being made at one end of the foundry and shaken out and pitted at the other end.

The sequence of operations is as follows:—The drag made on the first machine is lifted off by means of a trolley and transferred to a truck. Cores are set and a forward movement of the truck brings the drag under a trolley, serving the cope machine; the cope is set and mould cramped and then moved forward to a point in front of the cupolas for casting. After cooling somewhat, the trucks pass on, the boxes are opened and wheels lifted into the annealing pits. The sand when shaken out passes through a grating in a double deck hopper, where it is tempered and carried to a reciprocating conveyor, after which it is screened, cooled and delivered to the hoppers over each machine.

In each process the cupolas are operated continuously, and the effort in both cases is directed towards a regular sequence of moulding and casting.

Turning to the more familiar methods, these may be practically summed up in two classes, of straight and circular floors, plans of which are appended, showing the arrangement for an output of 325 wheels per day. The straight floor is the latest development, and can be operated within a smaller area than that required for the jib crane circular floor method. Thus the moulding department of the circular floor plant is given 39,960 sq. ft., while the straight line system requires only 21,580 sq. ft. for the same capacity, and the foundries, including other departments, cover 44,000 sq. ft. and 28,600 sq. ft. respectively. It will be seen that each row on the straight floor consists of 26 boxes, but the daily output row, or man, is 25 wheels. The two plans sufficiently show the arrangement followed, disposition of cupolas and annealing pits.

An interesting feature is found in the cupola charging machine shown in Fig. 3, designed by the Whiting Foundry Equipment Co., and installed in a number of newly erected wheel plants. By its use the charges are dumped into the cupola by means of an air hoist, which raises one side of the charging car to an angle of 40 degs., the other side remaining almost stationary. When in position in front of the charging door the hoist raises the floor plate on which

* The *Iron Trade Review*.

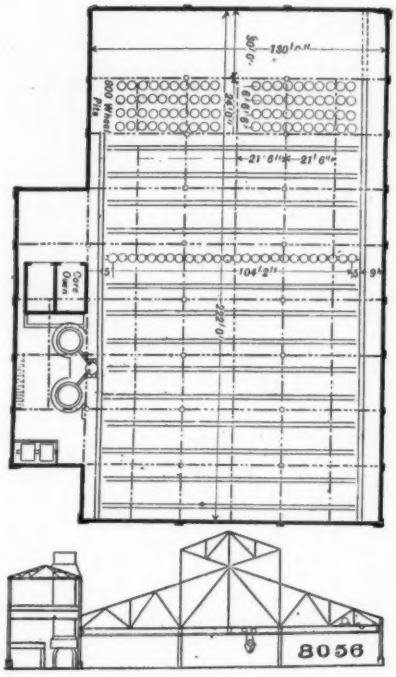


FIG. 1 —MODERN STRAIGHT LINE FOUNDRY.

the car rests, and to prevent it from sliding off the track the car is held in place by means of a hook which engages an eye fastened to the side sills. A steel plate lip extending from the charging door prevents any material dropping outside the cupola.

Finally, reference is made to the specifications and tests to which the wheels must conform. Wheels of 600, 650 and 700 lbs. weight are for cars of 60,000, 80,000 and 100,000 lbs. capacity respectively. Wheels of the same normal diameter must not vary more than $\frac{1}{4}$ in. above or below the mean size measured on the circumference, and on the same wheel must not vary more than $\frac{1}{16}$ in. in diameter. The depth of white iron must not vary more than $\frac{1}{4}$ in. around the tread on the rail line in the same wheel. The depth of chill is specified for the different weights, and any wheels not conforming will not be accepted. The drop test specified for a 600 lbs. wheel is that it shall withstand ten blows of a 200-lb. weight falling from a height of nine feet. Wheels passing this test are subject to the thermal test, which consists in moulding a

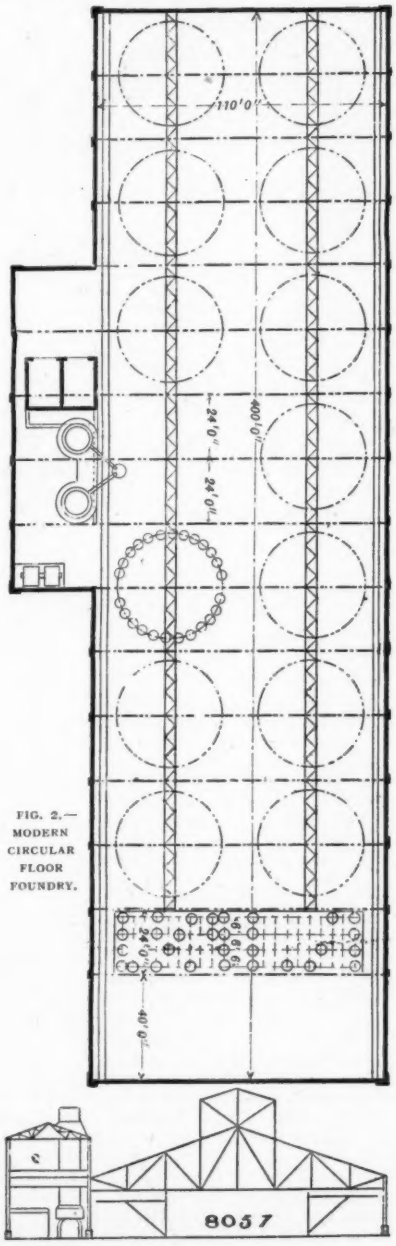


FIG. 2.—MODERN CIRCULAR FLOOR FOUNDRY.

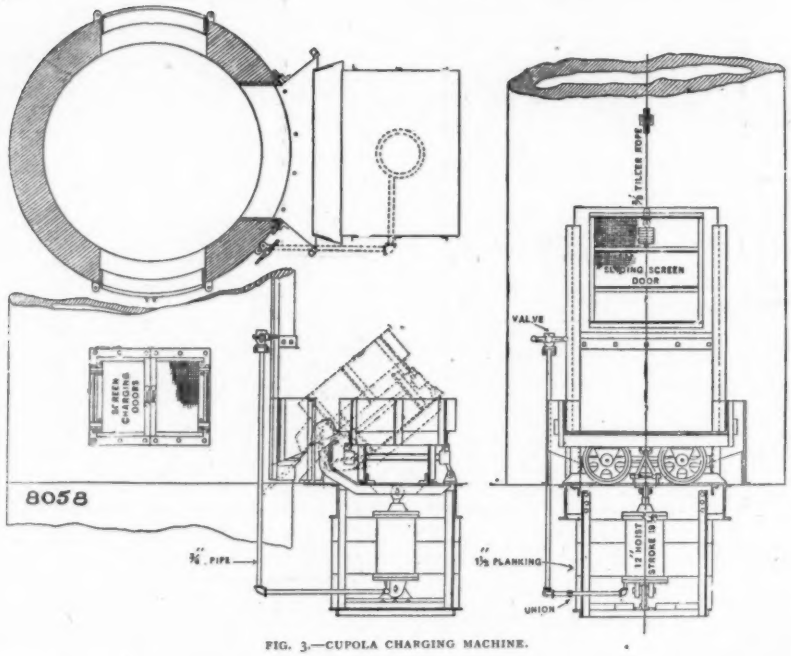


FIG. 3.—CUPOLA CHARGING MACHINE.

channel around the tread and filling it with molten metal. Two minutes after pouring the wheel is examined, and if found broken or if any cracks in the plate extend through or into the tread, the hundred wheels represented by the test are rejected. Notwithstanding the severity of these requirements, foundry losses in modern plants are stated to average less than 1 per cent., although 2 per cent. is considered normal working.

Steel Foundry Equipment.—An article in a recent issue of the *Iron Trade Review* describes at full length the new plant of The Detroit Steel Casting Co., and from it we note one or two special features having a direct interest to steel founders. In the first place an annealing oven is illustrated which presents a novel feature in that the roof is removable in segments, each segment being about 42 ins. wide, lined on its under side with fire-bricks, and provided with lifting hooks on the outer face to permit of removal by a crane. A large plate, which fits the bottom of the oven, is loaded with castings for annealing, lifted by means of a crane and lowered directly into the oven, and on placing the roof segments in position charging is completed. The oven may be fired by coal or oil fuel. The steel furnaces include two of the open hearth type of 15 tons capacity, which, however, permit of working 18 or 20-ton charges. Of special interest to British steel founders is the fact that these furnaces are worked by the basic process, and it appears that this process is gradually gaining a hold on the steel casting industry of the States. In this country the basic process has not met with very marked favour in the production of steel castings, and practically the majority of open hearth steel casting plants are confined to the acid process.

The Detroit furnaces are supplied with oil fuel, two burners of the "Kirkwood" type, one at each port, being used. Reversals are effected every 15 minutes, and the time of working down a charge is said to be six hours. A gas producer plant is located in line with the open hearth furnaces but has not yet been used, the oil fuel having given very satisfactory results. The furnaces are charged by means of a "Wellman-Seaver-Morgan" charging machine.

The converter castings department is supplied with two electrically operated

11-ton "Robert" converters. In this department small acid castings, such as those required in automobile construction, are made. Blast for the converters is supplied at a pressure of 3½ lbs. per square inch, and the liquid charges are obtained from a 54-in. "Collian" cupola located alongside the converters. Trimming shops in both open hearth and converter departments are supplied with pneumatic clippers, saws, stationary and portable emery grinders, &c.

Melting in Oil Furnaces.—Much interest is centred in these furnaces in view of their rapidity, cleanliness and ease of manipulation. They offer many possibilities to brass and malleable iron founders, or to grey iron founders working on a smaller scale, than can be adequately met by the cupola. One question of moment is found in the actual cost, or rather the saving effected by substituting oil for solid fuel, and statements by interested individuals are not always accepted in their entity. Mr. F. S. Fasig,* recording experience gained as a foundry foreman in making light brass castings, states that an oil melting crucible furnace, after thorough trial, gave unsatisfactory results from the point of quality and cost. On the other hand, a non-crucible double chamber furnace, in which one chamber is used for pre-heating, has given very satisfactory results. Costs compared with ordinary coal-fired crucible furnaces are as follows:—

Crucible.	
Coal per 100 lbs. of metal melted ..	24·4 cents.
Crucibles per 100 lbs. metal melted	14·0 ,,
	38·4 cents.

Oil Melting.	
Oil per 100 lbs. metal melted... ...	4·1 cents.
Crucibles per 100 lbs. metal melted...	2·5 ,,
	6·6 cents.

Crucibles in the case of oil melting are used solely for pouring.

Patterns for Pipe Bends.—In a recent issue of the *Foundry Trade Journal* an alternative method of making elbow cores is given. The usual method of strickling two half-cores in loam on a template is given, and the suggested method by which the full core is made in one operation is shown in Figs. 4, 5, and 6. The template (Fig. 6) is placed on a level bed of hard rammed sand and a channel strickled out by means of the strickle (Fig. 4). A layer of parting sand on

FIG. 4.

FIG. 5.

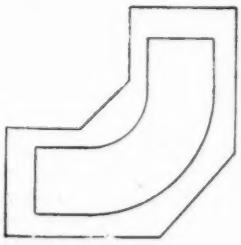


FIG. 6.

this gives the bottom part of a core box into which the sand is rammed, core iron and vents laid in the usual manner. The top half of the core is brought into form by means of the strickle (Fig. 5) working over the template.

STEEL.

Autogenous Welding of Steel.—A description of the Epurite process of welding steel lately adopted by the Worcester Pressed Steel Co. is given in a recent issue of the *Iron Trade Review*. The actual weld is made by a blow pipe using oxygen and acetylene arranged to give a neutral or reducing flame. The success of the operation lies in heating the pieces to the vicinity of their melting point without oxidation or carbonisation. The flame may be arranged to effect this and no flux is required in the process. The oxygen generator is charged with water and epurite and a solution of sulphate of iron allowed to flow into the generator to act as a catalytic agent. The liberated oxygen stated to be chemically pure is led into a gasometer, and from thence is pumped into a tank under a pressure of 150 lbs. A pipe leading from this tank runs the length of a bench where the outlet pipes for the operators are located.

NOTES AND COMMENT.

Car Wheels.—One of the most striking features in considering the American car wheel industry is the large output per moulder. A production of twenty-five 600-lb. wheels per day by one moulder and a labourer is an exceedingly good day's work. Whilst showing the value of specialisation, it also presents another

* The *Foundry*.

feature, in that this output is in the majority of cases obtained without the aid of mechanical moulding. True, all possible labour-saving appliances are utilised, but to all intents and purposes the moulds are hand-made. A similar feature may be noted in this country, and on certain classes of work, for example, railway chairs and colliery waggon wheels, hand-moulding successfully competes with machine moulding. The fact that on certain classes of repeat work hand-moulding, when provided with the necessary accessories, can show a large output at a very low cost of production, should prove an impetus to the further development of machine moulding.

Cupola Chargers.—We have on various occasions examined types of mechanical chargers, but the one illustrated possesses novel features which may or may not commend it to British foundrymen. As a rule the labour cost of charging is not excessive, but in the case of cupolas worked over long heats the idea is worth consideration.

Steel Founding.—Most engineers have a prejudice against basic steel which, so far as one can gather, appears to be founded on a fear of oxidation, that is, that the resulting steel will contain dissolved oxides of iron. This may or may not be the case, but at any rate the basic process has not made much headway in British steel foundry practice. That progress is being made in this direction in America is a matter for consideration, and the results should be carefully watched. Another feature of direct moment lies in the development of the surface and side blown convertors. These convertors are capable of yielding very hot and fluid steel, especially suitable for small intricate castings. In this respect they have been proved to possess advantages over the open hearth and crucible furnaces.

The Danger of Spraying Sewage into the Atmosphere.—In the course of a paper on the bacterial treatment of sewage, recently read before the Royal Sanitary Institute, Mr. W. D. Scott-Moncrieff emphasised the very grave objections which exist, on sanitary grounds and from the point of view of the public health, to the use of appliances which spray sewage into the atmosphere. Such apparatus has been adopted at Staines because there was practically no alternative, seeing that the existing beds had to be utilised, and in this case there are no houses in the immediate vicinity; but where large installations exist in the neighbourhood of towns Mr. Scott-Moncrieff is convinced that they will some day be identified as the immediate causes of the most serious outbreaks of zymotic disease, and that before long they will be absolutely prohibited. It is an extraordinary thing if the general community, which has been educated for years into the belief that sewer gas is dangerous to health, should be long content to accept the contradiction that the spray blown from these distributors in high winds, and which contains millions of pathogenic germs, can be breathed with impunity.

Cost of Working Motor Omnibuses.—The cost of working a thirty-four passenger petrol-motor omnibus of the better makes, under proper conditions, and running an average of 100 miles per day for 280 days per year, or 28,000 miles, was recently stated by Mr. Worby Beaumont to be as follows:

	Pence per Mile.
Depreciation at 20 per cent.	1'30
Driver and conductor	2'20
Tyres, per contract	1'75
Petrol, or fuel of other name, at 9*d.* per gal.	1'65
Oil and grease	0'15
Renewals and repairs	1'30
Washing, stabling, lighting and sundries ...	0'45
Insurance	0'40
Supervision, assistants, ticket service, and inspectors, sundries	0'38
Total working costs	9'56

The average receipts per motor-bus mile in London exceeds 13*d.* per mile. The difference between receipts and the new possible cost of working is thus fully equal to Mr. Worby Beaumont's expectations as stated on various occasions.

NEW MACHINERY AND APPLIANCES.

The Editor cordially invites early particulars of New Machinery, Improvements, Novelties, &c., for inclusion under this section.

Bevel Gear Planing Machine —"Sang" System.

An interesting form of bevel gear planing machine, operating on the same basis as the "Bilgram" and "Gleason" types of generators, is that manufactured by the Ateliers de Constructions Mecaniques (*ci-devant* Ducommun), Mulhouse, Alsace, and handled in this country by Messrs. Alfred Herbert & Co., Ltd., Coventry.

The design embodies a number of features of interest, among which are the linkage system, which imparts the proper movement to the blank, and the use of two tools, one for each side of the tooth. We are indebted to *Machinery*, *N.Y.*, for the following particulars and illustrations.

The machine operates on what is known as the "Sang" system, illustrated in its simplest form in Fig. 2. The master wheel and blank to be cut are given a lateral movement perpendicular to the axis of the shaft which connects them. This movement rolls the master gear over the rack giving the blank a similar rolling movement over a pair of cutters, which include a space corresponding in outline to the sides of the rack teeth. Thus these tools cut in the blank the tooth curves required to mesh properly with a rack whose teeth have the outline of the cutting tool edges. As shown in Fig. 1, when the pitch circle of the master gear rolls on the pitch line of the rack, a point such as K_1, will trace a cycloid K_1, K_2, K_3. A point J can be found so located that, with this as centre, an arc can be drawn very closely approximating the cycloid. If then, instead of the master gear and rack, we substitute, as shown in Fig. 1, a crank B_1 K_1, in place of the gear, and a link J K_1, to connect the crankpin with the point J, then, when the axis of the blank is given the lateral movement described in connection with Fig. 2, the link will so restrain the movement of the crankpin K_1 that it will nearly follow the cycloid.

The "Sang" process as applied to the forming of bevel gears is shown in Fig. 4. The rack is replaced by a crown gear, and the master gear is replaced by a master bevel gear whose axis passes through the central point of the crown gear. The gear to be cut is mounted on the axis of the master bevel gear and moves with it, and is so located that its pitch cone apex is at C, the centre of the crown gear. If, then, the sides of the teeth of the crown gear be plane

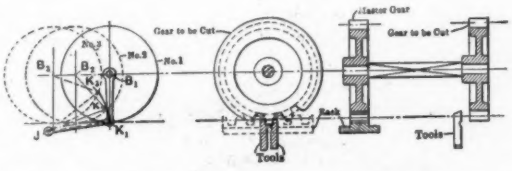


FIG. 1.—APPROXIMATE LINK MOTION.

FIG. 2.—"SANG" METHOD OF GENERATING SPUR GEARS.

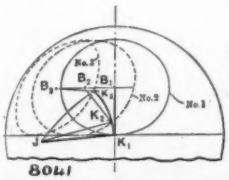


FIG. 3.—APPROXIMATE SPHERICAL LINK MOTION.

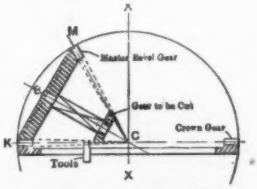


FIG. 4.—"SANG" METHOD APPLIED TO BEVEL GEAR GENERATING.

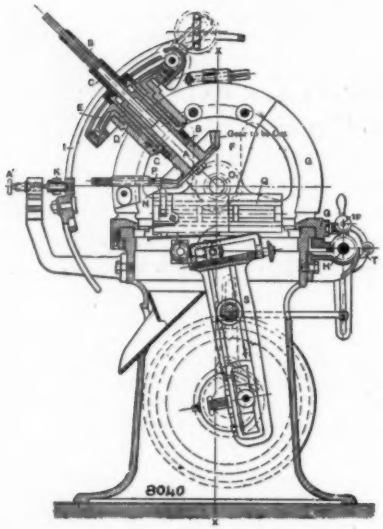


FIG. 5.—VERTICAL SECTION THROUGH PLANE OF WORK SPINDLE.

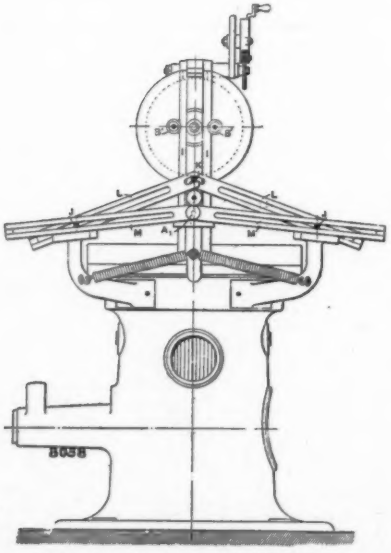


FIG. 7.—DIAGRAM SHOWING ARRANGEMENT OF APPROXIMATING LINKAGE.

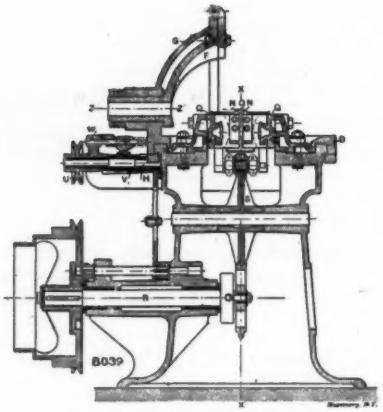


FIG. 6.—SECTION SHOWING DRIVING MECHANISM.

surfaces, a pair of tools with their cutting edges in the plane of the tooth faces of a rack space may be used to generate the teeth of the gear to be cut, when these tools are given a reciprocating motion which allows their cutting edges always to remain in the plane of the sides of the rack tooth. In this case the axis of the master gear and blank, instead of being given a rectilinear horizontal motion at right angles to the axis as in Fig. 2, is given a circular motion about vertical axis $X\ X$, so that line $B\ C$ would describe a cone if it were completely revolved. The master bevel gear is thus given the proper rolling motion about the crown gear.

By a similar approximation to that illustrated in Fig. 1, we may do away with the crown gear and the master bevel gear. The pitch circle of the master bevel gear rolls about the pitch circle of the crown gear. In so doing a point K_1 in the pitch circle of the master bevel gear will, as shown in Fig. 3, describe a spherical cycloidal curve determined by points K_1, K_2, K_3. Now, as in Fig. 1, we find a point J such that, with one point of the dividers located here, the other point will follow the spherical cycloid K_1, K_2, K_3 very closely. We may then, as in Fig. 1, dispense with the master and crown gears, replacing them with a crank or link, B_1, K_1, pivoted at one end to axis $B\ C$, and joined at the other end at point K_1 to the swing link pivoted at J. With this arrangement then, within reasonable limits, a rotation of axis $B\ C$ in Fig. 4 about vertical axis $X\ X$ will impart to the gear to be cut, through the restraining action of link $J\ K_1$,

a motion similar to that given by a master bevel gear and crown gear, which will be suitable, as before explained, for shaping the correct form of tooth on the blank under the action of the two cutting tools.

The machine uses two tools, shown at *N* in Figs. 5 and 6, mounted on separate slides travelling on guides *Q*, which may be adjusted independently about the vertical axis *X X* of the mechanism, in the circular recess to which they are fitted in the top of the frame of the machine. This adjustment gives the necessary converging motion to cause the teeth which they form in the blank to disappear at the apex *O* of the crown gear and the blank. A separate adjustment gives a rocking adjustment about axis *O* in the plane of the section in Fig. 5. This is required to make the tool follow the angle of the root of the tooth, and gives it a movement slightly out of the horizontal. The tool slides are reciprocated through ball pivoted connecting rods from the slotted link *S*, which has adjustments for varying the position and length of the stroke.

Axis *B C* in Fig. 4 is that passing through the gear to be cut in Fig. 5. The rotation of this axis about the vertical axis *X X* of the machine is effected by rotating the whole structure on which it is supported round a circular bearing at the top of the column. The table, carrying the structure for holding the gear blank, has a section for a worm wheel formed on a portion of its periphery. Shaft *H* may be driven either by pulley U, Fig. 6, from the belt cone for quick return movement, or by a cam in the face of the belt cone through the slotted link mechanism shown acting upon the ratchet and ratchet wheel at *T*, which arrangement gives the cutting feed. A clutch *V* connects either of these motions to shaft H. This clutch is operated by a rod *w* controlled by dogs, adjustable in the peripheral slot of the circular table. By means of these dogs the table, when started on the cutting feed, will stop itself at the conclusion of the cut, and rapidly return to its first position ready for starting in on a new tooth.

For the rolling motion which must be given the blank to agree with that of the master bevel gear rolling in a crown gear as shown in Fig. 4, the approximation outlined in Fig. 3 is used. Link *I* in Figs. 5 and 7 is link $B_1 K_1$ of Fig. 3. Point *K* in Figs. 5 and 7 is point K_1 in Fig. 3. In Fig. 7 pivot *K* has been raised from the position it should occupy directly back of point A_1, to show the construction of links *L*. Considering, however, that the mechanism is in its proper condition, when the blank is given its rotation about vertical axis *X X*, point K_1, if the proper rolling motion is given, the blank will trace a spherical cycloidal identical with K_1, K_2, K_3 in Fig. 3. To insure that point *K* shall follow with great exactness this cycloid, as the blank rolls to the left one of the pair of springs shown at the lower end of link *I* presses pivot *K* to the bottom of the open ended slot in link *L*, which is pivoted at point *J*, this point being selected in the same manner as point *J* in Fig. 3. Of course the cut is not started from the middle as we have been considering. The blank is first swung to the extreme right, for instance, so that it clears the tools. Under those circumstances the pivot *K* will bear on the bottom of the open ended slot in the right hand link *L*, being held there by the pressure of the right-hand spring. When it reaches the central position shown in Fig. 7 it will be under the restraining influence of both links *L*. As it continues to swing towards the left it will come under the control of left-hand link *L* and the left-hand spring.

The machine is semi-automatic, the indexing being done by hand.

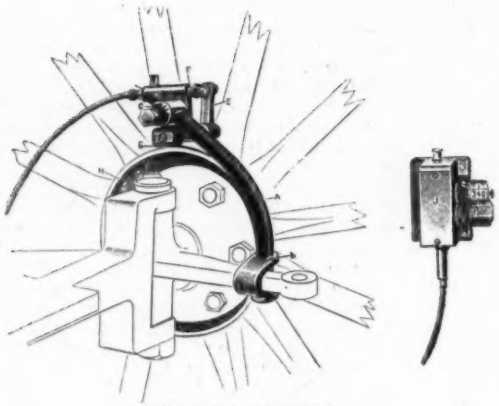
A New Mileage Recorder.

For reasons which are obvious, the dashboard is the position most favoured for placing a mileage recorder, but to many motorists a recorder so placed has hitherto not proved an unmixed blessing. In the first place it has been a somewhat costly article to buy, and, in the second, it has had to rely upon a flexible shaft to transmit the tale of miles from the wheel to the recording dial, and the flexible shaft is, without doubt, one of the least reliable of mechanical contrivances.

The latest emanation from the works of E. M. Bowden's Patents Syndicate, Ltd., however, claims to settle both difficulties at one stroke, as the "Bowden" wire is substituted for the flexible shaft, and the price is fixed at a lower figure than with any other form of dashboard positioned recorder.

The general appearance of the recorder will be easily understood from the following description and the illustration.

That part of the instrument which fits to the dashboard occupies only a space of three inches square. The mechanism, which is of a simple and durable nature, is enclosed in a brass casing, heavily nickel-plated, and consists mainly of a hardened steel pawl and ratchet wheel with spring return. The axle carrying the ratchet wheel is extended



NEW MILEAGE RECORDER.

through the case and terminates in a toothed wheel carrying a pin which engages in the star wheel of the mileage recorder *J*. This mileage recorder, although attached to the same base plate as the rest of the mechanism, is entirely self-contained, and can be removed from its fixings without interfering with any other part of the device. The fitments at the road wheel end of the device consist of a round rod of mild steel *A* having a clip *B* at one extremity in order to fasten it to one of the steering arms of the car, and where it is necessary to bend this rod the work can easily be done by any motor repairer or blacksmith. This rod carries an adjustable arm *C*, which, by means of a set screw, can be fixed at any desired height. It is made to carry the "stop" *D* in which the outer member of the "Bowden" mechanism terminates, and also accommodates a bell-cranked lever *E* working on a hardened pivot. At one end of the bell-crank is a plunger *F* carrying a length of the inner member of the well known "Bowden" flexible wire mechanism. The other end is made to take a fibre pad *G*. Screwed to the spokes of the road wheel, or fastened to the hub flange, is an eccentric drum *H*, which imparts a rocking motion to the bell-crank, thus pulling on the inner member of the "Bowden" wire mechanism and actuating the recorder *J* on the dashboard.

Part of the mechanism has been purposely left exposed, so that one may readily see that the instrument is not "missing." Should this occur, the most likely reason is the bedding down of the wires, and the remedy is to extend the adjustable stop found at either end of the encased wire.

As some may doubt the capacity of the "Bowden" wire to withstand the frictional strain under the quick reciprocal movement, such as here involved, we are assured by the makers that the wire has been tested for the purpose to over eighty millions of movements at high speed before giving out, while, of course, the wire can be renewed at any time at a trifling cost.

Samuel's Patent Drawing Pen.

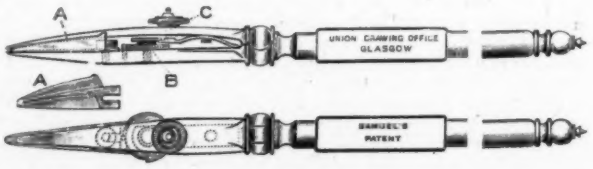
Below is an illustration of a new and improved drawing pen which is now being put upon the market.

The object of this construction is stated to be an improved quality of lines drawn in reduced time.

The pen is fitted with an opening arrangement, which, by turning the milled nut *B* a quarter of a turn, permits the pen to be instantly opened and closed, for and after cleaning or ink filling, without disturbing the adjusting screw *C*, thus enabling uniform and clear lines to be drawn without loss of time in adjusting or trying the pen.

The point of the pen is similar to an ordinary one, but in addition is fitted and used with an enclosing steel nib *A*, of channel section, which receives and permits the hinged leg of the pen to be adjusted within its sides for the width of line required. This nib, which is removable for cleaning, &c., in the same way as the ordinary writing pen nib, holds and encloses the ink free from evaporation, so that the pen can be used continuously without choking, and it is stated that pens have been used on fine line work for over two hours without cleaning or refilling.

Full particulars may be obtained from The Union Drawing Office, St. Vincent Street, Glasgow, who are the agents for the inventor.



UNION DRAWING OFFICE PEN

The Engineer's Book-shelf

Experimental Electro Chemistry. By N. MONROE HOPKINS, Ph. D. (London: Constable & Co.) 12*s.* net.

As a rule chemists are not distinguished by their electrical knowledge, and *vice versâ* electricians are not always familiar with the science of chemistry. Electro-chemistry necessarily implies familiarity with, at any rate, the elementary stages of chemistry and physics, and the reader possessing this knowledge will find in Dr. Hopkins a reliable guide and laboratory companion. Although we have indicated a certain amount of preliminary training as essential to a full appreciation of the book, it is only just to add that the author's style is so clear and direct, his explanations so lucid, that the reader not possessing this preliminary knowledge will still find much of value within the book.

Another aspect of the work is found in the fact that apart from its value as an exponent of the science of electro-chemistry it also constitutes a remarkably good history of the subject.

A History of Chemistry. By ERNST VON MEYER, Ph. D. Translated by G. McGowan, Ph. D. (London: Macmillan & Co.)

This is the third English edition of a book which in its earlier form had attained a considerable measure of success. As the work deals with practically the whole period covered by chemistry, that is down to "the present day," it is obviously too large a field to cover in a detailed review. Generally speaking the impression left on completing the book is that it has been written by a master of his subject, and that the translation has been done by one thoroughly in sympathy with the original author. To the technical chemist the work will prove of value, in that it presents admirable reviews of applied chemistry, and fair indices of the position of to-day. However, it is the student reading for examination and the general reader who will probably read the book most. The student will find facts accurately presented, and he can arrange his reading to cover any particular period or to isolate the work of any special pioneers. The general reader will find the book to be most "readable," the period covered is one of great interest, and in a sense touches on the birth and development of most industries. A perusal of the book most forcibly illustrates the far-reaching arm of chemistry, and emphasises the dependence of industrial development on advancing chemical knowledge.

O'Gorman's Motor Pocket Book. By MERVYN O'GORMAN, M.I.E.E., A.M.I. Mech. E. With 301 illustrations. Second Edition. (London: Archibald Constable & Co., Ltd., 1907.)

The second edition of this handy volume has been considerably amplified to include the numerous developments that have taken place since the appearance of the first edition a year or two ago. The original alphabetical arrangement has been preserved, while Italian has been added to the foreign equivalents of automobile terms, a feature which is likely to meet with the appreciation of those motorists who are of a more than usual roaming disposition. Although the prime object of the book is instruction, the new edition nevertheless touches on controversies which have raged over automatic *v.* mechanically operated valves; solids *v.* pneumatics; trembler coil *v.* non trembler; electric *v.* steam *v.* petrol, &c.; a feature which adds considerably to the interest of the book.

Although arranged in dictionary form motorists will nevertheless find that the work is distinctly readable, apart entirely from its value as a work of reference.

Notes on Construction in Mild Steel. By HENRY FIDLER, M.Inst.C.E. (London: Longmans, Green & Co., 39, Paternoster Row, E.C., 1907.) Price 16*s.* net.

This work has been arranged primarily to suit the requirements of junior draughtmen, and presupposes a proper grounding in the theory of construction and an elementary knowledge of the determination of stresses. Some idea of the scope of the volume may be gathered from the titles of the chapters which deal with —1. Mild steel: its manufacture, physical and chemical quilities. 2. Rolled sections in steel and their mechanical elements. 3. Upon certain applications of riveted girder work. 4. On the practical design of columns and struts. 5. Roof construction in mild steel and iron. 6. Mild steel and iron in marine engineering. 7. The protection of steel surfaces from corrosion.

The volume scarcely needs any recommendation, as, coming from the pen of Professor Fidler, it cannot fail to prove most helpful to

the student in the study of steel construction, and generally to all who are interested in the application of a material which occupies so important a position in engineering and architectural construction.

Concrete-steel and the protection of constructional steel-work from the effects of fire are not dealt with, the author reserving these for separate treatment hereafter.

The Chemical Analysis of Iron. By A. A. BLAIR. Sixth edition. (J. B. Lippincott Co , Philadelphia and London.)

The majority of steel works chemists are familiar with Blair's "Analysis of Iron," and the fact that it is now in its sixth edition speaks well for the utilitarian character of the book. The present edition is chiefly marked by the addition of methods for the analysis of high speed steels. A careful study of the book and personal test of many of the methods given indicates the work to be of a very reliable character, and we have every confidence in recommending it to those interested in the analytical chemistry of iron.

Producer Gas. By J. EMERSON DOWSON, M.Inst.C.E., M.I.Mech.E., and A. T. LARTER, B.Sc., F.C.S. (London: Longmans, Green & Co.) Price 10s 6*d.* net.

Although much has been written on gas producers, we know of no book in which the important and somewhat involved problems connected with this subject are explained in such a masterly and lucid manner as in the volume before us on producer gas. All are aware of Mr. Emerson Dowson's long practical association with the application of producer gas for power and heating purposes, and in the production of anthracite semi-water-gas he must assuredly be thoroughly steeped.

This book is not only printed in a large, clear type, but is capitally illustrated by diagrams, by the help of which the reader is taken through the whole course of gas production in easy stages.

Examples of the most important forms of producers used for power, furnace, and other heating purposes are illustrated by clearly drawn sectional drawings, by which are explained the construction and working of the regenerative furnace producer, the several types of bituminous-coal gas producers, and last, but not least, that most modern development, the suction producer, enough examples of which are given to illustrate the trend which this useful adjunct to the gas-engine is taking.

The comparison of gas-power *versus* steam-power is forcibly and graphically illustrated, and shows at a glance the proportions of unavoidable wastes, and the power capable of being utilised in the two systems.

The book would be incomplete without some reference to the methods used for ascertaining the composition and heating value of gas; the most useful apparatus for this purpose being described and illustrated in a very clear manner.

In leaving no question unanswered, this work should certainly be kept for reference by all who are interested in the many uses of producer gas, which include in addition to power and furnace work used in connection with the iron and steel trade and allied manufactures, such other applications as heating ovens, muffles, &c., brazing, heating buildings, &c., and for the many other purposes where heat capable of being obtained in an economical and efficient manner is a necessary part of the process.

A Practical Treatise on Modern Gas and Oil Engines. By FREDERICK GROVER, A.M.Inst.C.E. and M.I.Mech.E. (Manchester: The Technical Publishing Co.)

In the writing of this little book of 360 pages or so on modern explosion engine practice the author had evidently set-out with the intention of compiling information that would be useful for engineers employed in the designing and testing of explosion engines. The reader will find, however, except for the historical part which is interestingly sketched, far too much space taken up in the description of obsolete engines, and may look in vain for much information on really modern gas or oil engine practice. The illustrations, too, are for the most part just outside views and cannot afford much assistance to the designer. The book, moreover, contains very little relating more particularly to the design of large gas engines; and further, in connection with gas apparatus, the author has confined his remarks principally to the Mond producer.

The chapters on oil-engines include *inter alia* a few rather crude sketches of vaporisers, many of which, it may be stated, have long gone into disuse; the part dealing with spirit-motors is still more limited, not extending very far beyond a description of the old "Spiel" and early forms of "Daimler" engines, which, needless to add, will not help the reader much.

There is notwithstanding much useful information on apparatus used in indicating engines, sampling gas and conducting tests, on which subjects the author adduces much that may be serviceable; and if in this edition more attention had been devoted to this part, instead of essaying to treat on the whole subject of explosion engines in general, the work would have had a more practical value.

THE ENGINEERING PRESS.

In this section is presented every month a list of the more important articles appearing in the Engineering Press and of the leading papers read before the various engineering institutions. Full names, addresses, and published prices of the publications indexed are printed each half-year in the volume index.

Civil Engineering.

Concrete Bridges with three swivels, on the Iller, at Lautrach and Kempten, Bavaria. *Le Génie Civil*, 16*th February*, 1907.

A Powerful Dredge equipped with a cable Storage Drum. *Engineering News*, 7*th February*, 1907.

Khushalgarh Bridge. *Engineering*, 22*nd February*, 1907.

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Irrigation Works at Kom-ombo, Upper Egypt. *Engineer*, 8*th March*, 1907.

The Construction of the Pennsylvania Railroad Tunnels under the Hudson River at New York City. By James Forgia, II. *Engineering News*, 28*th February*, 1907.

Torpedo Boat Docks at the Kiel Imperial Ships Yards. By Dr. Gradenwitz. *International Marine Engineering*, *March*, 1907.

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Economic Design of Reinforced Concrete. *Engineering News*, 21*st February*, 1907.

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The Requisite Temperature for Ferro-concrete Buildings. By G. de Grahl. *Beton u Eisen*, *February*, 1907.

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Reinforced Concrete. By H. N. Allott, M.Inst. C.E. *Practical Engineer*, 1*st March*, 1907.

The Line of Advance in Wood Preservation. By Carl G. Crawford. *Engineering News*, 7*th February*, 1907.

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Boiler Feed Piping. By R. T. Strohm. *Electrical World, New York*, 2*nd February*, 1907.

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Modern Steam Traps (*continued*). *Practical Engineer*, 22*nd February* and 8*th March*, 1907.

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Testing and Purchasing Coal for Steam Plants. By A. O. Doane. *Engineering News*, 7*th February*, 1907.

Steam and Exhaust Pipes. Some considerations of their Arrangement and Defects. By R. McGregor. *Electrical Times*, 21*st* and 28*th February*, 1907.

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Venturi Meter, I., II. *Practical Engineer*, 15*th* and 22*nd February*, 1907.

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Electrical Coal-cutting by Bar Machines, with special reference to the "Simplex" Machine. By A. Hall. *Iron and Coal Trades Review*, 1st *March*, 1907.

The Construction of Overhead Electric Transmission Lines. By A. P. Trotter. *Transactions Institute Civil Engineers*, 5*th March*, 1907.

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The Battleship of the Future. By F. E. Cardullo, I. and II. *Scientific American*, 9*th*, and 16*th February*, 1907.

Modern Electrically-Equipped Shipbuilding Berths. *Electrical Review*, 1st *March*, 1907.

The Screw Propellor, VIII. By A. E. Seaton. *Marine Engineer and Naval Architecture, March*, 1907.

The Deformation of Propeller-blades. By Wm. Burlingham. *Engineering*, 1st *March*, 1907.

The Application of Electricity to the Driving of Pumping Machinery for Pontoon and Graving Docks. By W. C. Mountain. *Transactions North-East Coast Institution of Engineers and Shipbuilders*, 1st *March*, 1907.

Marine Steam Turbine Development. By Hon. C. A. Parsons and R. J. Walker. *Transactions North-East Coast Institution of Engineers and Shipbuilders*, 15*th March*, 1907.

Water Supply.

Different Methods of Purifying Water. By P. A. Maignen. *Proceedings Engineers' Club, Philadelphia, January*, 1907.

Sewage.

The Municipal Sewage Experiment Station, of Waterbury, Connecticut. By Wm. Gavin Taylor. *Engineering News, 28th February*, 1907.

Engineering Economies Works Management.

The Establishment of a Piece-work System, I. By E. G. Tiegehen. *Mechanical World, 1st March*, 1907.

Works Organisation Simplified. By W. O. Horsnaill. *Electrical Engineering, 7th March*, 1907.

Miscellaneous.

The Commercial Application of Refrigeration. By Hal Williams, M.I.Mech.E. *Journal Society Arts, 22nd February*, 1907.

The Co-operation of Chemistry and Engineering in Science. By Dr. George Lunge. *Zeitschrift des Oesterreichischen Ingenieurs und Architekten Vereines, 15th* and *22nd February*, and *1st March*, 1907.

The National Physical Laboratory as a Commercial Testing Establishment. *Engineer, 15th February*, 1907.

Ethics of Trade Secrets. By F. P. Fish. *Proceedings American Society Mechanical Engineers, February*, 1907.

Electric Furnace Methods of Iron and Steel Production, III., IV. By John B. C. Kershaw. *Electrician, 22nd February* and *8th March*, 1907.

Denatured Alcohol. By H. Leffmann. *Proceedings Engineers' Club, Philadelphia, January*, 1907.

Resistivity Temperature Formulæ for Copper. By Dr. F. B. Crocker. *Electrical World, New York, 23rd February*, 1907.

Steel Rails and the Passing of the Bessemer Process. By Benj. Taylor. *Times Engineering Supplement, 13th February*, 1907.

High-Speed Steels for Woodworking.—The result of a series of tests made by one of the largest woodworking establishments in the U.S.A. appear to show that the high-speed steels are destined to bring about as great an improvement in woodworking as they have done in the machining of metals. According to the *Iron Age* the tests brought out these general facts :—

The rate of feed may be nearly doubled.

The cutting knives keep an edge from 3 to 10 times as long as the old steels.

The knives may be ground with a better edge.

The sharpening of knives may be done to advantage without removing them from the head.

A slower speed of knife head is entirely practicable.

Most interesting, and probably most important of all, is the knowledge that the real value of the new steels in woodworking lies in the high finish given to the wood. Taking a test of planing as an example, carried out on both hard and soft woods at the rate of 105 ft. per minute, instead of a succession of knife marks there was a clean surface possessing a glossiness similar to that obtained in a sanding machine.

A Self-starting Gas Engine.—According to the *Engineering Record*, a self-starting gas engine has recently been designed in which compressed air is employed for starting, but not by the usual method of temporarily using one cylinder as an air motor. The engine has five cylinders and an arrangement of crank-shaft and valve-mechanism by which one inlet-valve is partly or wholly open at all times. Compressed air is delivered directly to the intake in starting, from which it will enter the open cylinder. The compressed air is admitted through a closed-type carburettor, a check-valve in the intake preventing its escape at this point; and the engine begins to turn over until all five cylinders have thus received a charge of combustible mixture. At this time, the first cylinder has compressed the charge admitted to it, and is then fired in the usual way, starting the engine. In the starting, while each piston is rising on the compression stroke, the exhaust valve of its cylinder is lifted by a cam to relieve the pressure somewhat, and prevent compression to the point of pre-ignition. These cams are operated by a single lever interlocked with the compressed air supply; and they are thrown out of action when the compressed air is shut off, after the engine is started. The compressed air supply is furnished by a pump attached to the valve-shaft, which is automatically controlled to maintain a pressure of 100 lbs. in a storage tank.

TRADE LITERATURE.

The Chloride Electrical Storage Co., Ltd., Clifton Junction, Manchester. Circular No. 17. Batteries and Highfield boosters in alternating-current stations. Circular No. 18. Accumulator for train lighting.

John Abbot & Co., Ltd., Gateshead-on-Tyne. Illustrated pamphlet descriptive of this firm's works and productions.

Ernest Scott & Mountain, Ltd. List No. 73 of electric pumping machinery. The catalogue contains a useful series of tables which should prove of value to practical mining engineers.

Scottish Motor Engineering Co., Ltd., Edinburgh. 1907 catalogue of the "Granton" Motor Omnibus.

Snowdon, Sons & Co., Ltd., Millwall, E. List dealing with "Sinol," a new cylinder lubricant to take the place of oils.

Crompton & Co., Ltd., Salisbury House, London Wall. Illustrated list, Section 8, of switchgear.

Alfred Herbert, Ltd., Coventry. Sectional catalogue, edition 5, 1907, of combination turret lathes.

Brillig Light Co., Berwick-on-Tweed. Pamphlet descriptive of the "Brillig lamp" which makes its own gas from motor spirit.

Edison & Swan Co., Ltd., Queen St., E.C. Leaflet No. 1. 2083 of a new type of sector pattern, moving iron type ammeters and voltmeters, specially suitable for motor work.

A. Borsig, Berlin. From the firm's London agent, Mr. R. Weatherburn, Finsbury Pavement House. Catalogue of heavy locomotives.

S. Wolf & Co., 138, Southwark St., E.C. Catalogue of portable electric drilling machines.

Wm. Foster & Co., Ltd., Lincoln. Illustrated pamphlet descriptive of the "Wellington" tractor.

W. H. Bailey & Co., Ltd., Salford. List No. 107 of Whitmore's patent sight-feed, tell-tale lubricator and filter.

Ludw. Loewe & Co., Ltd., Farringdon Rd., E.C. New and enlarged edition of their pamphlet on limit gauges.

Empire Roller Bearings Co., Ltd., 15, Victoria St., S.W. 1907 list of roller bearings for railway and tramway stock and all kinds of rotary machinery.

MANUFACTURERS' NOTES.

J. Conway & Co., Hunslet, Leeds, have amalgamated with Messrs. Beanland, Perkin & Co., Leeds. Mr. Conway will act as manager of the second-hand machinery department.

Messrs. Dean, Smith & Grace, Ltd., Keighley, are making considerable extensions to their works. They comprise a new foundry two and a half times the area of the present one, and also considerable extensions to the erecting shops. The new erections are of steel, the whole of the roofs being of Haywood's Patent Glazing, with steel-framed side windows. An additional cupola to melt eight tons per hour and a number of modern type core drying stoves are to be installed and the plant of moulding machines largely increased. All the machines in the foundry will be electrically driven. Embodied in the scheme of extensions are new sidings from the Midland Railway. On this the rail track is on a level with the cupola staging, enabling all material to be taken direct from the truck on to the staging, while sand, gas coke, ganister, &c., are thrown from the truck through gratings to the grinding and mixing machinery which is placed underneath, while the coke is taken direct from the truck to the boilers by means of a conveyor.

Messrs. W. & T. Avery, Ltd., advise us that the East Indian Railway Co. are just having despatched to their order fifty weighing machines for use on their different stations for weighing luggage. These machines have a capacity of 40cwt. and 56 maunds, and by the use of Avery's Patent Polygonal Bar the weight can be read in either standard, thus preventing any confusion as to charges, and also a great saving in time.

The Kennicott Water Softening Co., 18 & 19, Great St. Helens, E.C., have received an order from the Krupp Gun Works at Rheinhausen, Germany, for a 20,000 gallon per hour, Type "A," water softener.

PRIZE COMPETITION FOR ENGINEERS.

WITH the object of encouraging readers of THE ENGINEERING REVIEW to communicate their ideas and experience on subjects of engineering interest, we have decided to give

A PRIZE OF £10

for what is, in the opinion of the Editor, the best article on one of the undermentioned subjects, under the conditions given below.

SUBJECTS.

1. The Relative Value of Planing and Milling.
2. Electrical r. Mechanical Driving.
3. Bonus Systems of Payment for Labour.

INSTRUCTIONS AND CONDITIONS.

Competitors must be subscribers to THE ENGINEERING REVIEW.

Articles must not contain less than 2,000 words, and must be written on one side of the paper only, and be signed by the competitor.

Drawings and sketches must be on separate sheets of paper.

A short biographical sketch of the competitor's technical experience should accompany the article.

The right is reserved of publishing the prize article, and also any of the others sent in; but in the case of the latter, payment will be made for the same at our usual scale rates.

The Editor's decision in all matters connected with the competition shall be final, and binding on all the competitors.

All articles should be addressed to the Editor of THE ENGINEERING REVIEW, 104, High Holborn, London, W.C., and marked on the outside, "Competition," and the same must be received not later than May 1st.